

PV Market Update

Modified from Q4 2017/Q1 2018 Solar Market Update

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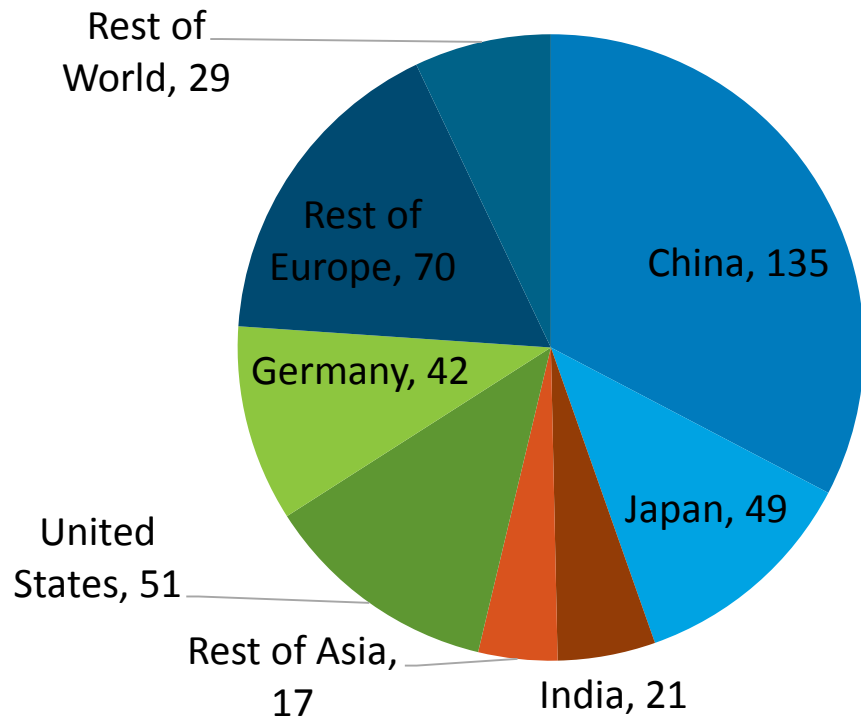
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MOSAIC Annual Review Meeting, May 15th
– 16th, 2018

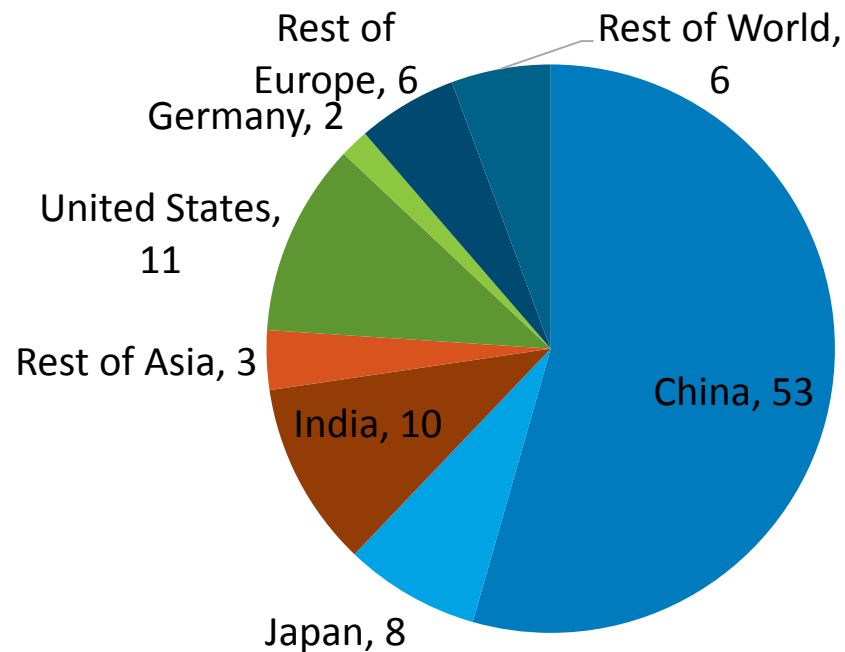
Markets and Installations

Top PV Markets

Cumulative PV Deployment - 2017 (415 GW)



Annual PV Deployment - 2017 (98 GW)



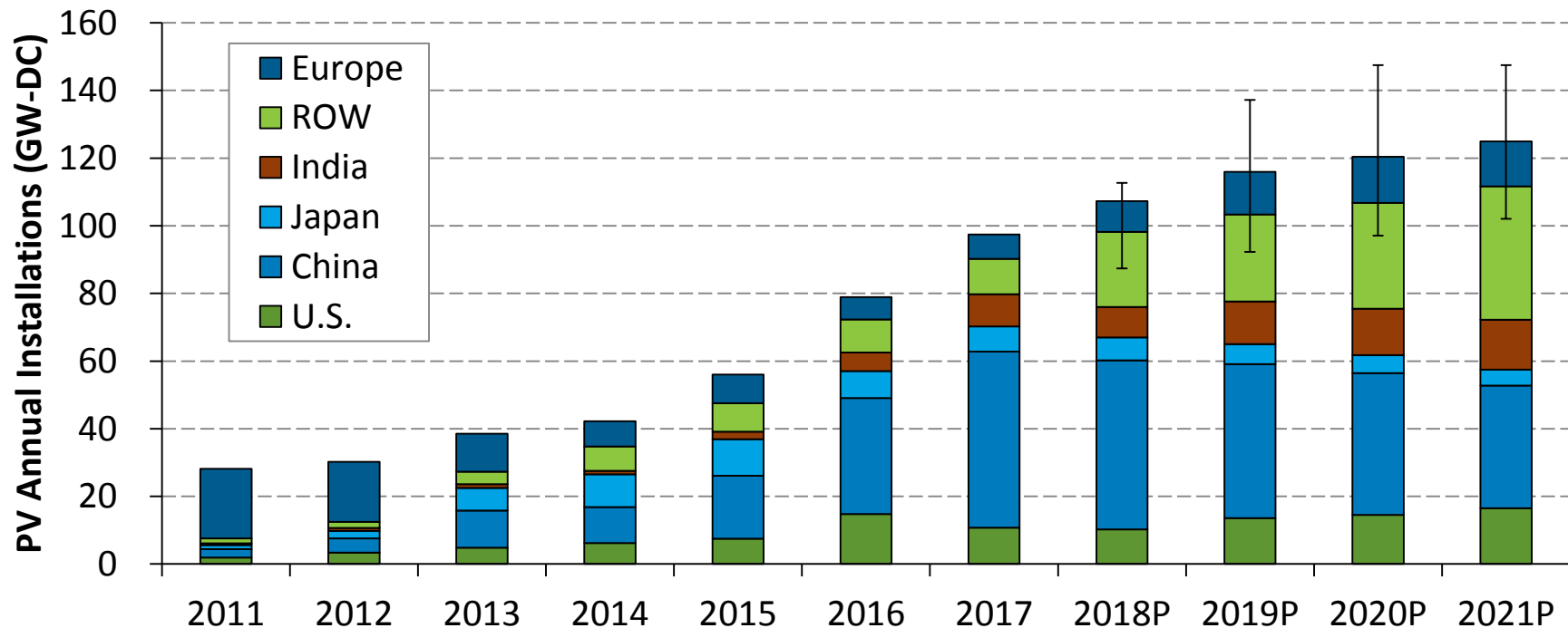
Chinese Market Update

- BNEF attributes China's record 53 GW of new PV in 2017 to the sudden increase in quota allocation by the Chinese government in August 2017.
- Of the 130 GW of PV installed at the end of 2017, BNEF estimates that 30 GW were distributed PV (70% of which were located on rooftops).
 - Going forward, BNEF expects a higher percentage of rooftop PV systems in China
- Anticipated FiT cuts lead to an expected installation rush in Q2 and Q4 of 2018.
- BNEF reports that policies supporting greater renewable integration, along with power demand growth, helped reduce solar curtailment to 6% in 2017.
 - However, certain regions suffer from curtailment as high as 16%; to address this, China has reduced build-quotas in these regions.

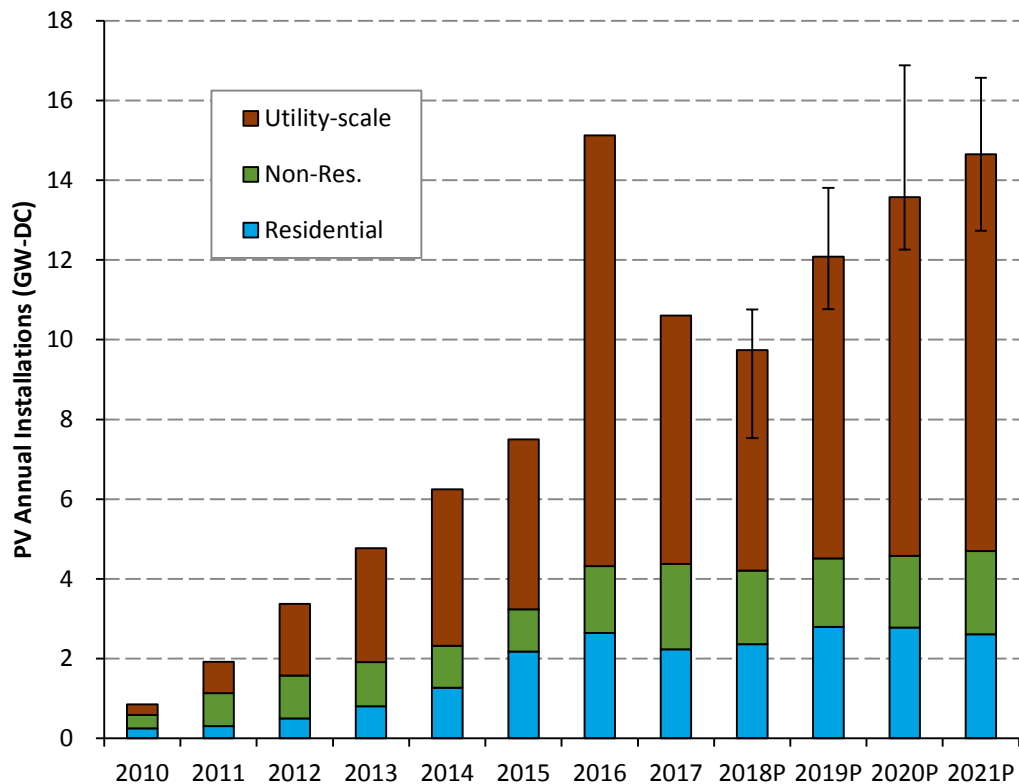
Annual Global PV Demand

The median analyst figures estimate 470 GW of PV will be installed globally from 2018 to 2021, more than doubling current installed capacity.

Annual Global PV Installations by Market



Annual U.S. PV Demand Projections

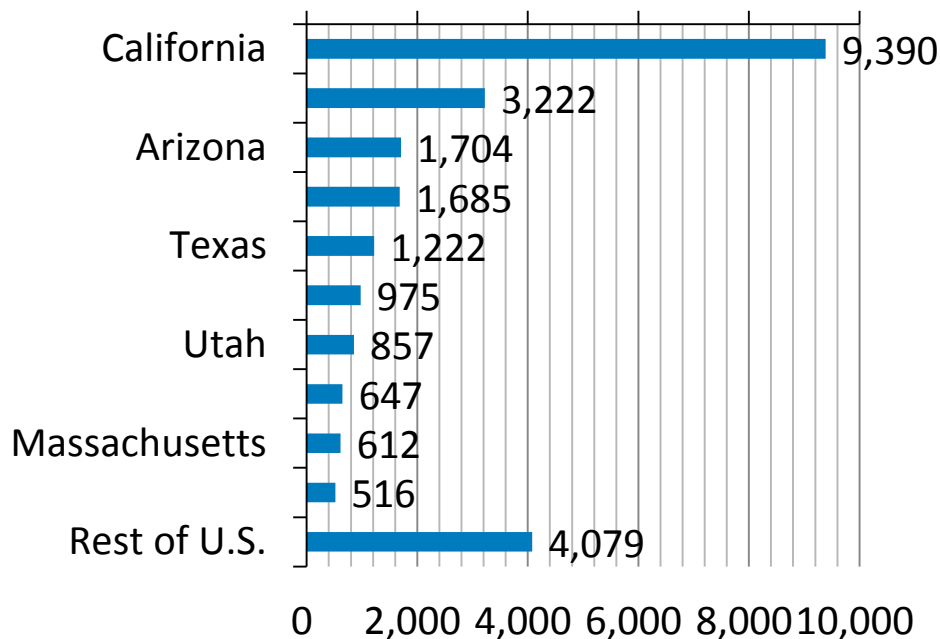


- The United States installed 10.6 GW-DC of PV in 2017, cumulative capacity reached 51.6 GW.
- The drop in deployment is expected to come mostly from the utility-scale sector, with only the residential sector expanding.
- Market contraction in 2017 and 2018 has been attributed to:
 - Section 201 tariffs on PV modules
 - Pipeline depletion caused by the 2016 rush to obtain a 30% tax credit (which was later extended through 2019)
 - A lull in deployment before the 2019 rush to obtain the full federal tax credit before it begins declining in 2020
 - Slowing of growth in the top U.S. markets.

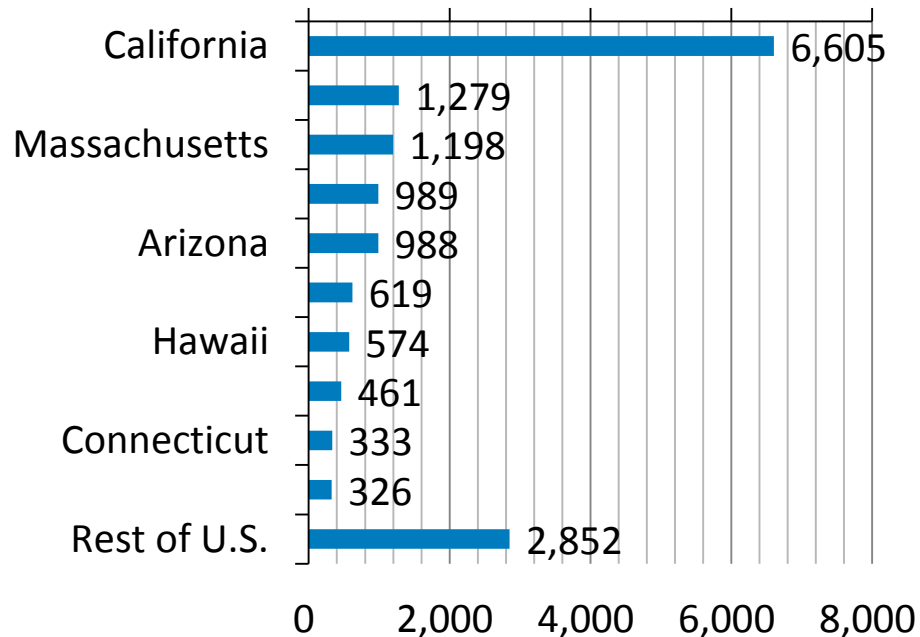
U.S. Installation Breakdown by State

In 2017, new PV installations have had a fair geographic mix across the United States, with 5 GW-DC installed east of the Mississippi.

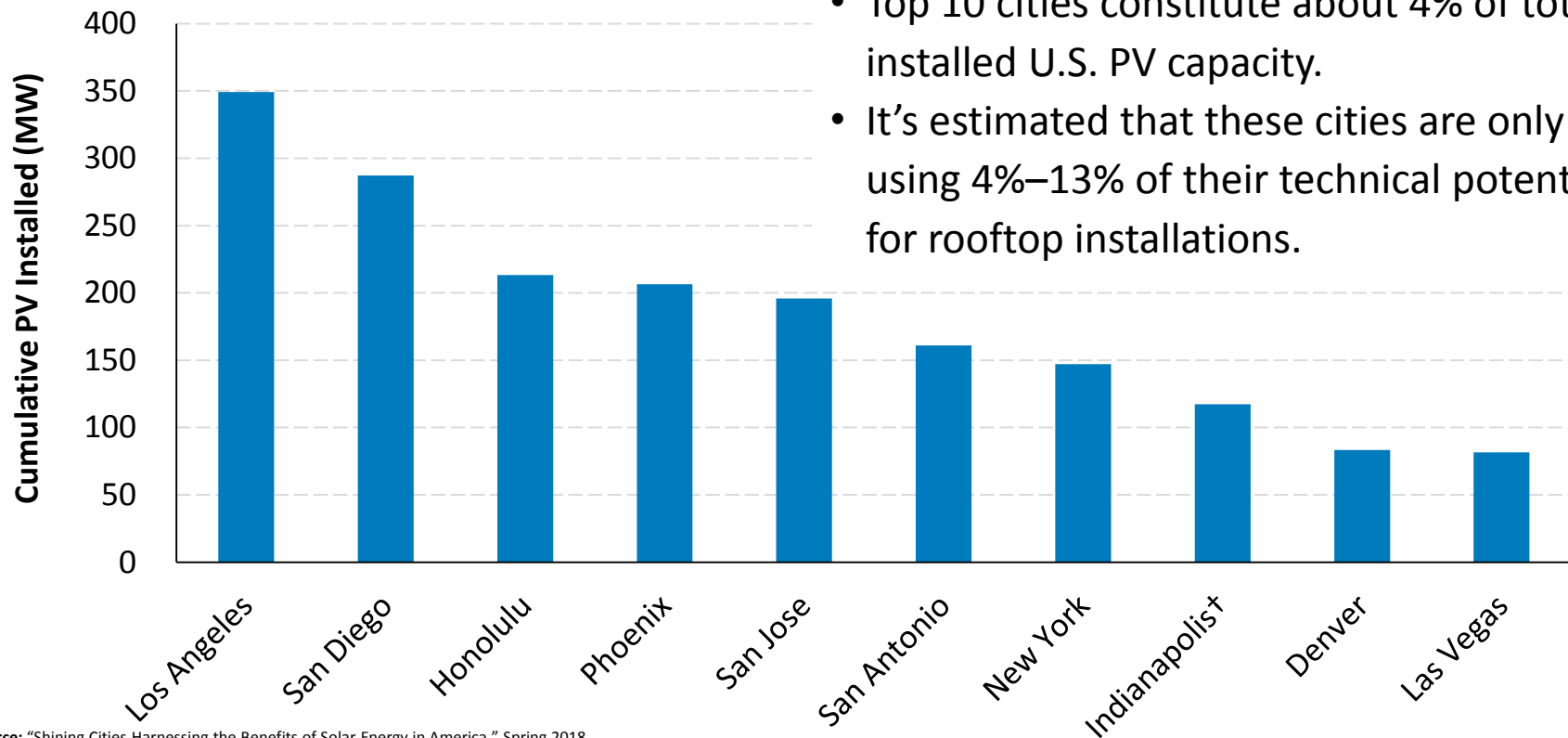
UPV Installed Capacity, Top 10 States, as of December 2017 (MW-AC)



DPV Installed Capacity, Top 10 States, as of December 2017 (MW-AC)

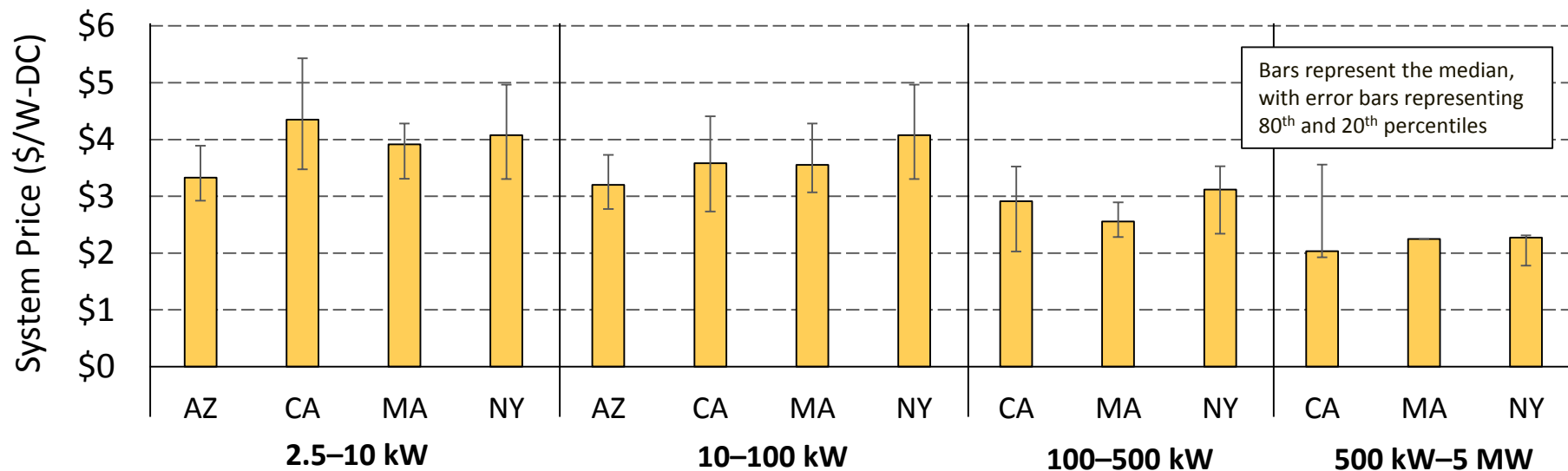


Leading U.S. Cities



System Pricing From Select States, H1 2018

In addition to price differences based on system size, there is also variation between states and within individual markets.



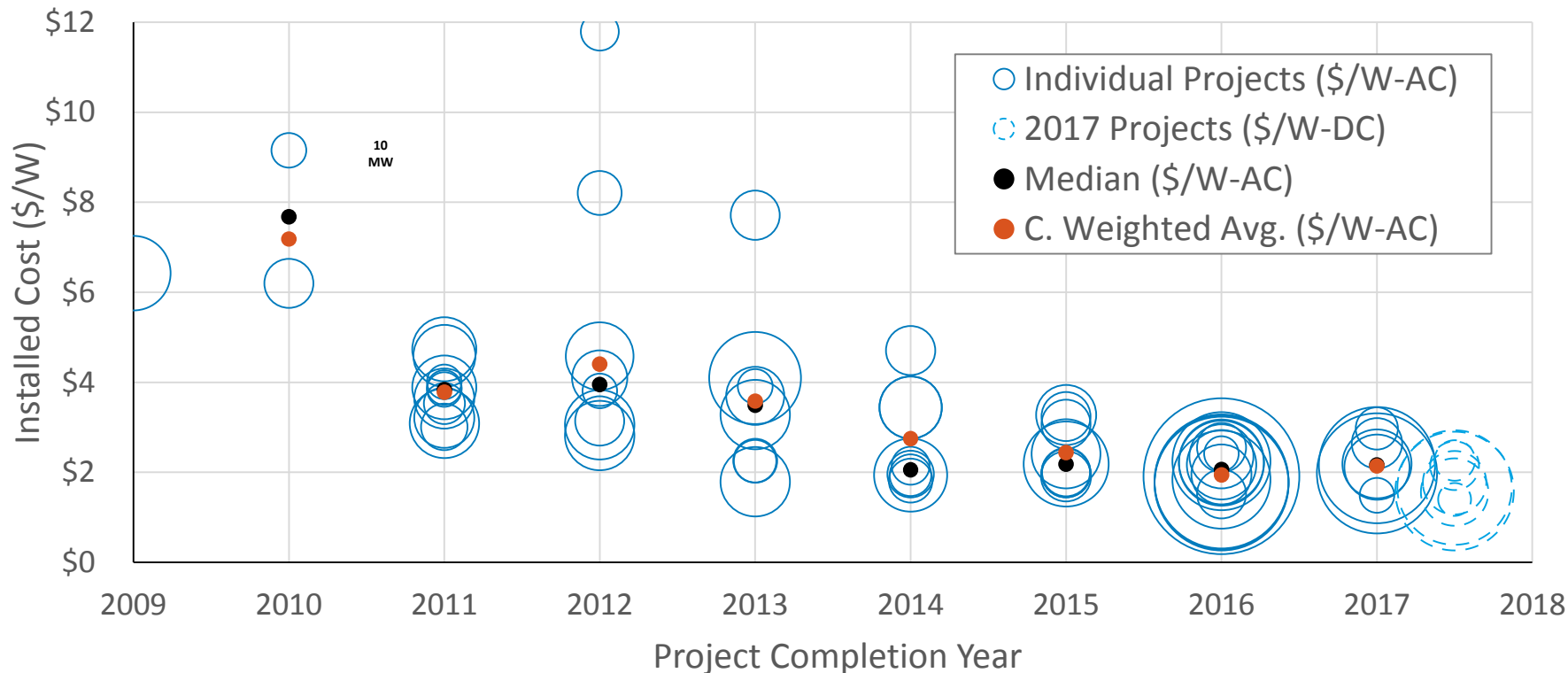
Preliminary H1 2018 MW: AZ (48), CA (47), MA (13), NY (72)

Note: California pricing data before 2015 are collected from the California Solar Initiative database. CA NEM data have only been reported through November 2017.

Sources: CA NEM database; MA SREC program; Arizona Public Services and Salt River Project; NY PV Incentive Program. All programs accessed 01/17/2018.

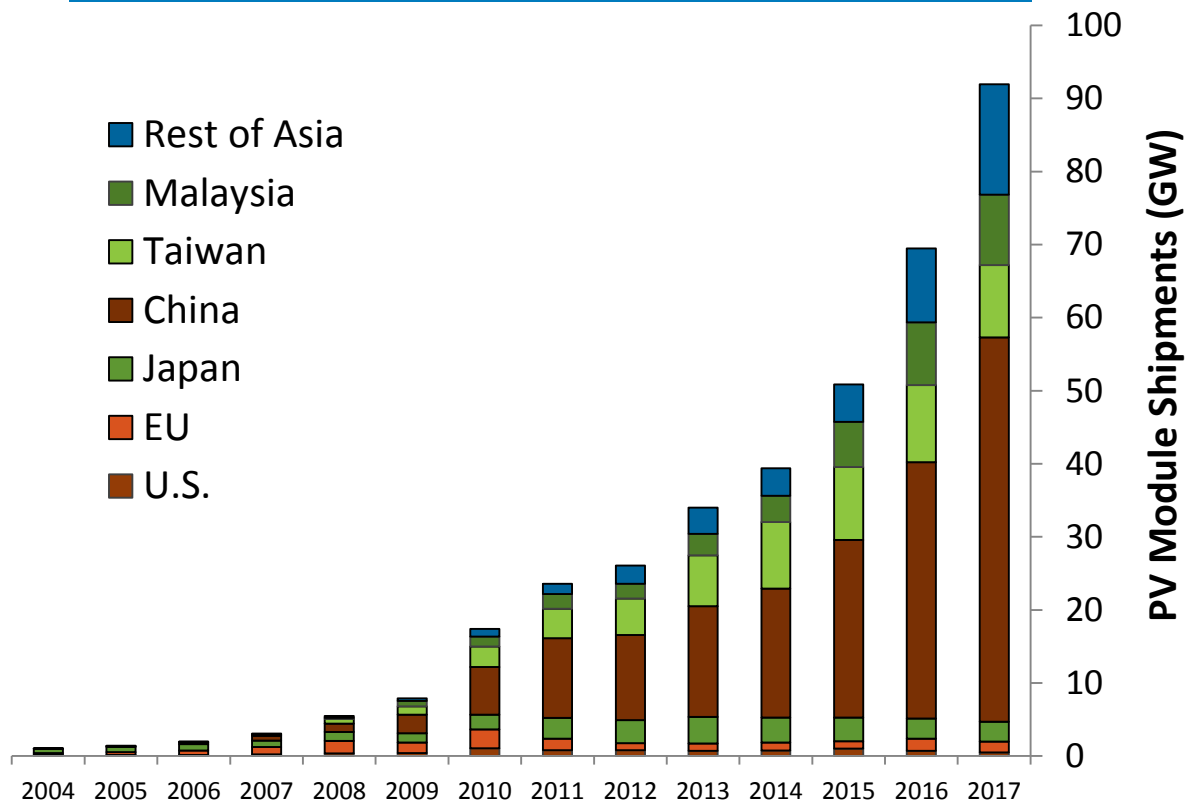
Utility-Owned PV Pricing (>5 MW)

In a select data set of utility-scale PV systems (68 projects totaling 1.4 GW-AC) from 15 regulated utilities, the median system price in 2017 was \$2.16/W-AC (\$1.66/W-DC).



Manufacturing and Supply

Global Annual PV Shipments by Region*

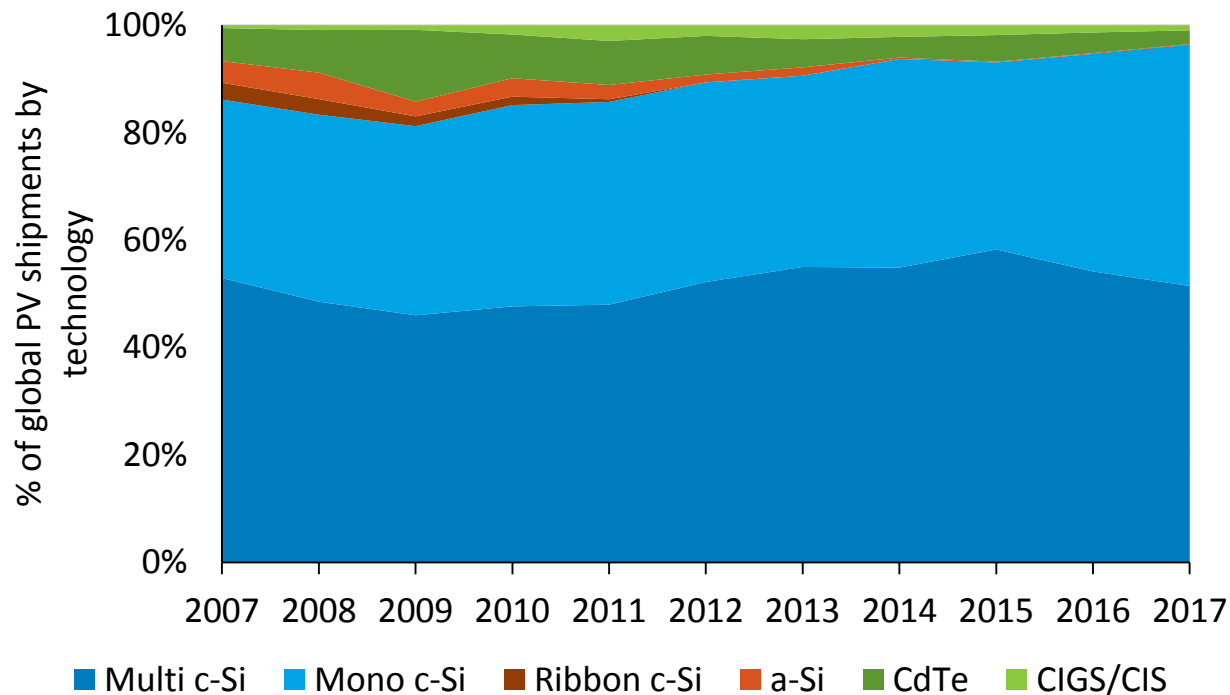


- From 2004 to 2017 the CAGR of global PV shipments was 41%, with growth coming mostly from Asia.
 - In 2005, Japan, the United States, and Europe shipped 92% of global PV modules, falling to 5% in 2017.
 - The United States supplied approximately 0.5% of global PV modules in 2017.

*Note: Excludes inventory sales and outsourcing.

Source: 2007-2017: Paula Mints. "Photovoltaic Manufacturer Capacity, Shipments, Price & Revenues 2017/2018." SPV Market Research. Report SPV-Supply6. April 2018.

Global Annual PV Shipments by Technology*



- Mono c-Si grew its global market share from 35% in 2015 to 45% in 2017 as companies ramped p-type PERC manufacturing.
- Thin-film technologies continue to lose market share, falling to 4% in 2017.

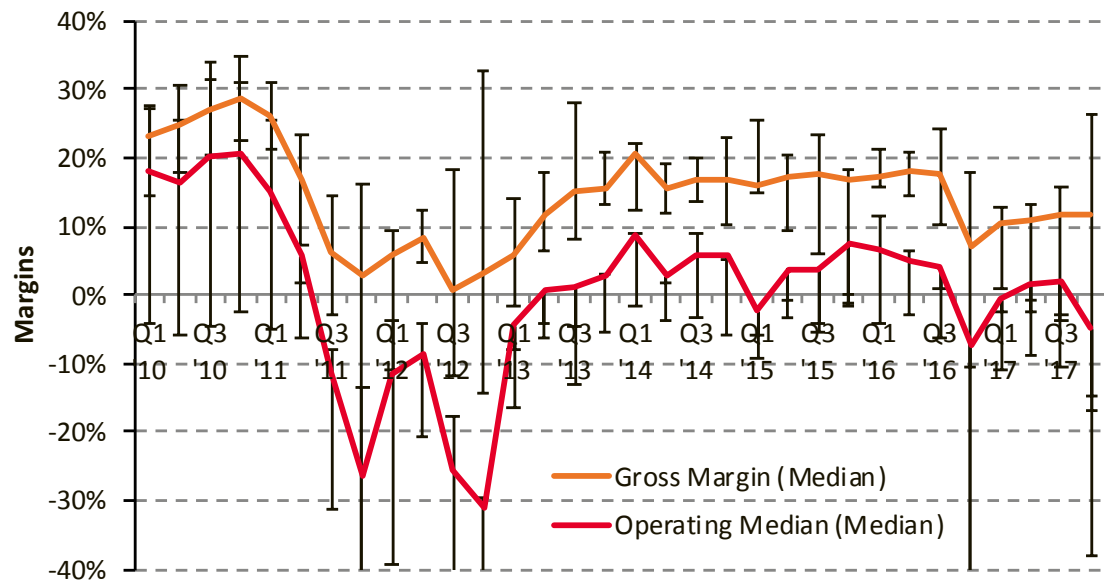
***Note:** Excludes inventory sales and outsourcing.

Sources: 2007-2017: Paula Mints. "Photovoltaic Manufacturer Capacity, Shipments, Price & Revenues 2017/2018." SPV Market Research. Report SPV-Supply6. April 2018. PVTech (April 2018).

Global Leading PV Manufacturers, by Shipments

Rank	Manufacturer (2017)	Shipments (GW)	Manufacturer (2016)	Shipments (GW)	Manufacturer (2007)	Shipments (GW)
1	JA Solar	6.5	Trina	5.0	Sharp	0.4
2	Canadian Solar	5.4	JA Solar	4.9	Q-Cells	0.3
3	Zhongli Talesun	5.0	Hanwha	4.0	Suntech	0.3
4	Jinko Solar	4.9	Jinko Solar	3.9	Kyocera	0.2
5	Trina Solar	4.8	Motech	2.9	First Solar	0.2
6	LONGi	4.5	First Solar	2.7	Motech	0.2
7	Hanwha	4.2	Longi Lerri	2.7	Sanyo	0.2
8	Tonjwei	3.8	Canadian Solar	2.4	SolarWorld	0.1
9	Motech	3.2	Yingli	2.4	Mitsubishi	0.1
10	Aiko	3.1	Shunfeng-Suntech	2.2	SunPower	0.1
Other		45.5		36.4		1.0
Total		91.9		69.5		3.0

PV Manufacturers' Margins



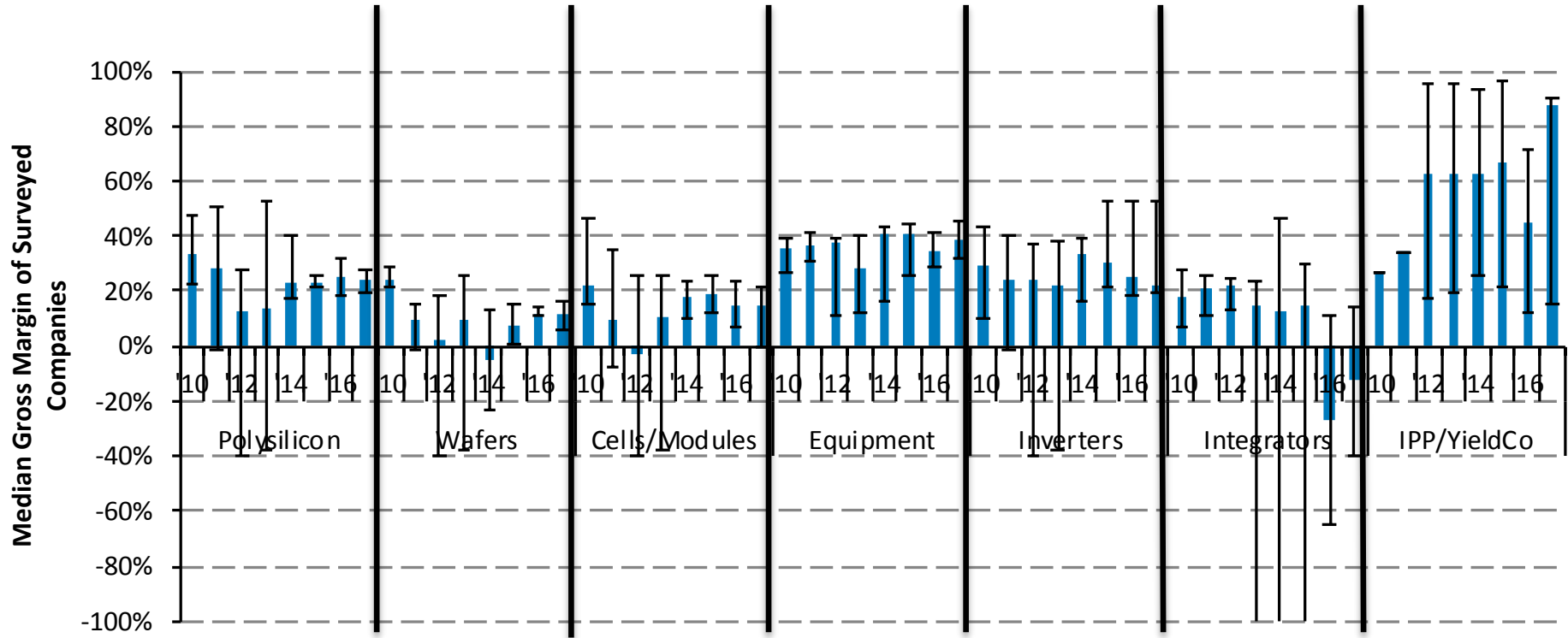
- The tracked companies had almost no change in median gross margin in 2017. However, there was a sharp fall in the median operating margin, from 2% in Q3 2017 to -5% in Q4 2017.
 - The lower operating margin was not necessarily systemic as the companies with lower margins reported:
 - Lower reported quarterly sales due to project delays (First Solar)
 - One-time bad debt expense (Hanwha)
 - One-time impairment charge of residential lease assets (SunPower)

Line represents the median, with error bars representing 80th and 20th percentiles for the following companies: Canadian Solar, First Solar, Hanwha Q Cells, JA Solar, Jinko Solar, SunPower, and Yingli Solar.

Sources: Company figures based on Q4 2017 (and previous) SEC filings by the respective companies.

Gross Margin Across Supply Chain

- YieldCos continue to get higher margins than other sectors of the supply chain, with wide variance among individual Yieldcos, which had gross margins ranging from 15% to 90% in 2017.

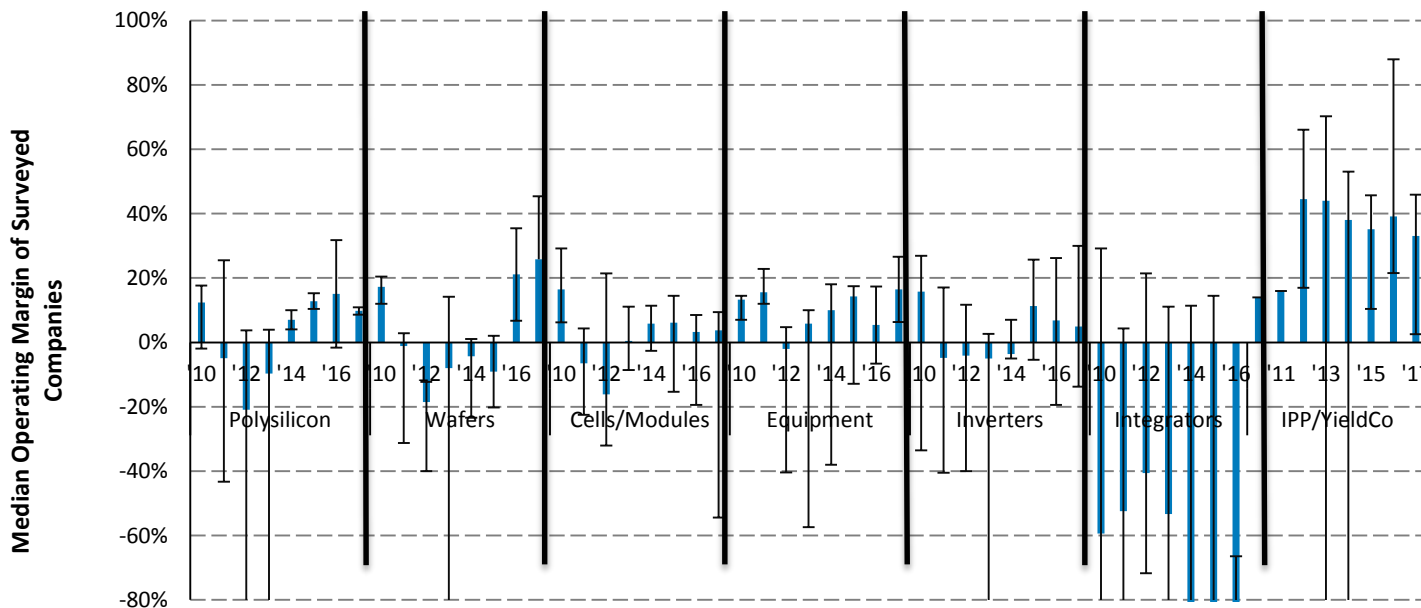


Sources: Company figures based on Q4 2017 (and previous) SEC filings by the respective companies. Error bars represent high and low values of surveyed companies. Companies surveyed are: Wafers - LDK Solar, ReneSola, SAS Wafers, Wafer Works Corp., Solargiga; Poly - GCL-Poly, REC Silicon, Wacker, LDK Solar; Cells/Modules, Gintech, Motech, First Solar, JA Solar, Yingli, Trina Solar, Canadian, PV Crystalox Solar, Hanwha SolarOne, Jinko Solar, SunPower, LDK Solar; Integrators - Real Goods Solar, SolarCity, Vivint, SunEdison; Inverters - Power-One, SMA, Satcon, Enphase Energy, Advanced Energy Industries; IPP/Yieldco - Abengoa Yield, NRG Yield, NextEra Energy Partners, Northland Power Inc., Pattern Energy, Terraform Power, Sky Solar Holdings.

Operating Margin Across Supply Chain

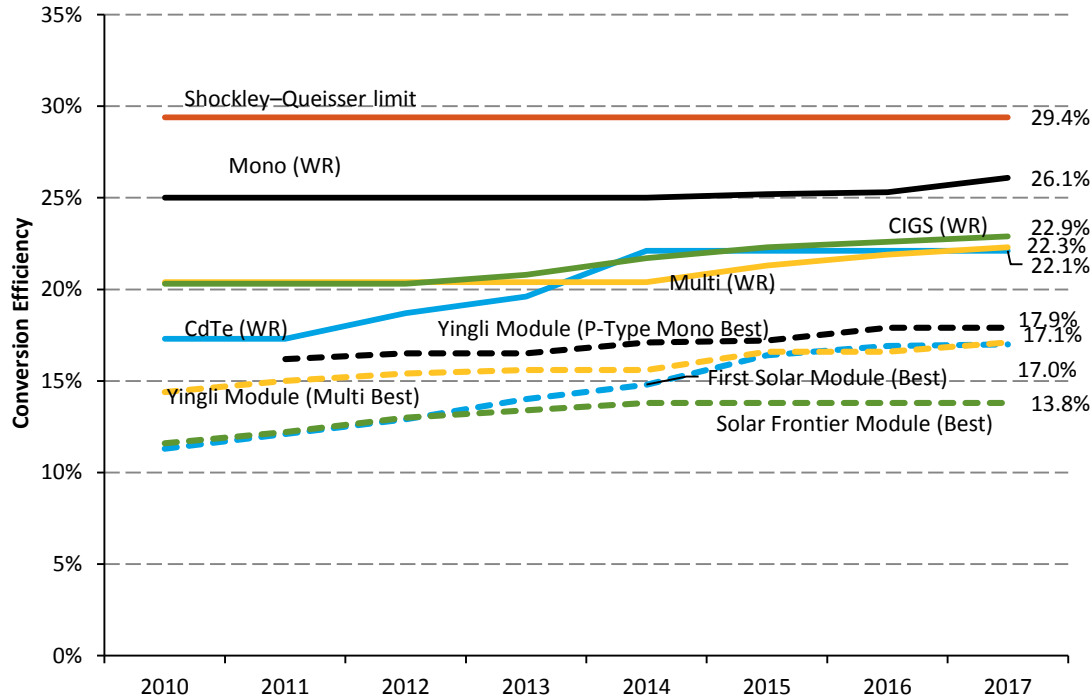
Operating margin is not necessarily an indicator of corporate profitability, though with strong margins companies should eventually figure a way to profitability.

- There was a wide variation in operating margins in 2017 as companies tried to gain market share and pursue new strategies.
 - There was substantial variation across the supply chain as integrators sacrifice short-term profits to scale rapidly.



Sources: Company figures based on Q4 2017 (and previous) SEC filings by the respective companies. Error bars represent high and low values of surveyed companies. Companies surveyed are: Wafers - LDK Solar, ReneSola, SAS Wafers, Wafer Works Corp., Solargiga; Poly - GCL-Poly, REC Silicon, Wacker, LDK Solar; Cells/Modules, Gintech, Motech, First Solar, JA Solar, Yingli, Trina Solar, Canadian, PV Crystalox Solar, Hanwha SolarOne, Jinko Solar, SunPower, LDK Solar; Integrators - Real Goods Solar, SolarCity, Vivint, SunEdison; Inverters - Power-One, SMA, Satcon, Enphase Energy, Advanced Energy Industries; IPP/Yieldco - Abengoa Yield, NRG Yield, NextEra Energy Partners, Northland Power Inc., Pattern Energy, Terraform Power, Sky Solar Holdings.

PV Efficiency Improvements



Note: WR denotes "World Record."

Sources: Corporate press releases and public filings, NREL World Records.

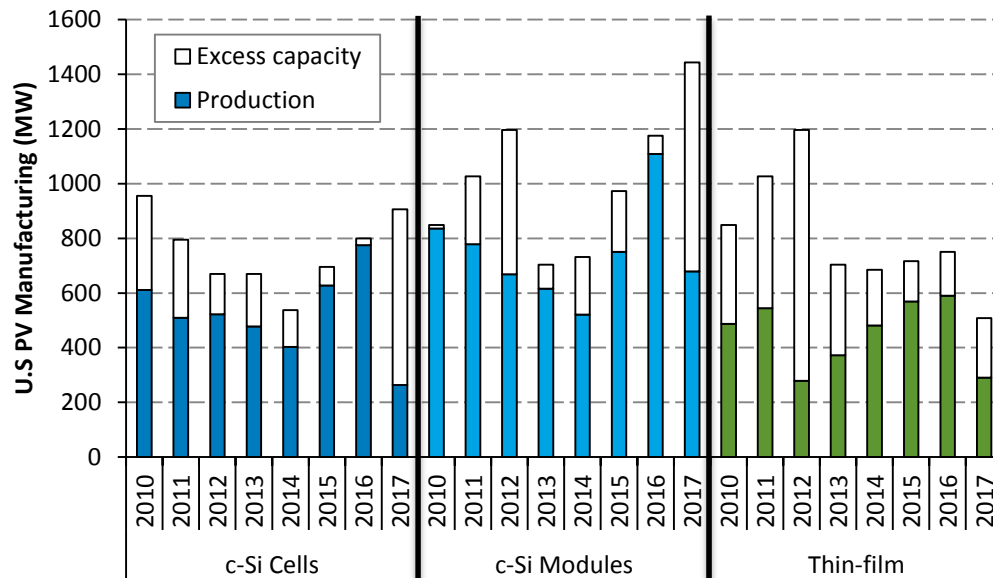
- Mono c-Si, multi c-Si, and CIGS all achieved world records in the lab in 2017.

- Despite Solar Frontier's world record achievement for CIGS, the company continues to sell modules well below the efficiency of other products.

- CdTe now has virtually the same module efficiency as multi in the marketplace.

- Standard p-type mono modules still have a ~1% efficiency advantage over multi and CdTe.

U.S. Module and Cell Manufacturing



- Due to an increased competitive landscape, U.S. manufacturers closed down production lines to switch to more advanced designs (e.g., First Solar) or caused by bankruptcies (e.g., Suniva, SolarWorld).
- In 2017, the United States produced approximately 260 MW of PV cells and 970 MW of PV modules—a decrease of 66% and 43%, respectively, year over year.
 - U.S.-produced c-Si cells represented 39% of U.S.-produced c-Si modules in 2017.
 - U.S.-produced PV modules represented 9% of annual U.S. PV installations in 2017.
- U.S. c-Si cell, c-Si module, and thin-film module manufacturing had utilization rates of 29%, 47%, and 57% in 2017, respectively.
 - With the implementation of tariffs on imported PV modules in the beginning of 2018, and First Solar’s Series 6 production ramp-up, the United States has the potential to produce significantly more PV modules and cells in 2018.

Section 201 Trade Case & Other Trade Updates

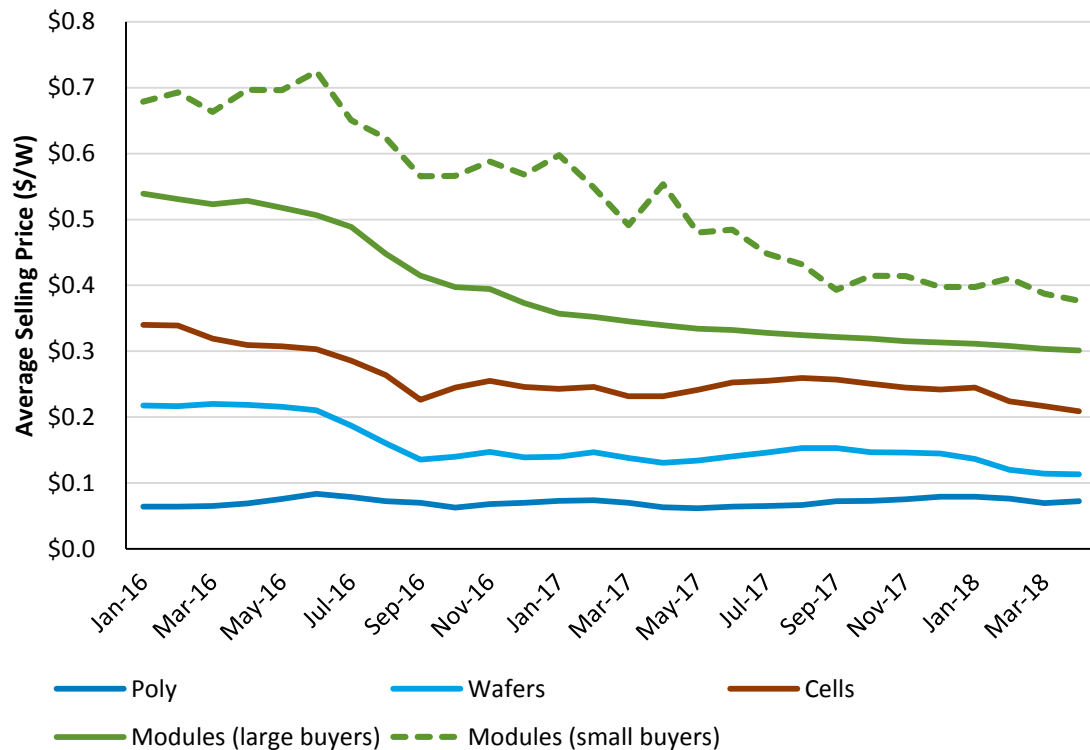
- On February 7, 2018, the United States began imposing safeguard tariffs for imported c-Si PV cells and modules.
- The tariffs begin at 30% ad valorem in 2018 and decrease to 15% by 2021
- Exemption on the first 2.5 GW of imported PV cells per year.
- GTM Research's updated U.S. PV deployment forecast in March 2018 was 13% lower than what was projected before the tariffs were put in place.
- In addition to the module and cell tariffs, the U.S. codified new steel (25%) and aluminum (10%) import tariffs, which GTM Research estimates will add an additional 2%–5% to PV system costs.

U.S. Manufacturing April Updates

- **JinkoSolar** confirmed it plans to invest \$50MM to build a **400 MW module assembly plant in Jacksonville, Florida**. Jacksonville city council had approved \$24MM in incentives to attract a foreign manufacturer.
- **SunPower** announced it would purchase **SolarWorld Americas**. It plans to use the Oregon cell and module factory (**currently with 430 MW of cell and 500 MW of module capacity**) to manufacture its lower efficiency P-Series solar panels, as well as SolarWorld legacy products.
- **First Solar** announced it would make an initial \$400MM investment in **Ohio to build a 1.2-GW** capacity plant to manufacture its large-format **Series 6 modules**, employing 500 workers.
 - **This would triple its U.S. manufacturing capacity and bring its global manufacturing capacity to 7.6 GW** (with plants in Malaysia and Vietnam).
 - **Instead of the tariffs, First Solar cited recent U.S. tax reform and “favorable business environment”** as reasons for its decision. It also said that its **new large format cells reduce the labor benefits of producing panels abroad**.
 - Their CEO said the new factory can **also leverage its R&D and existing manufacturing in Ohio**.

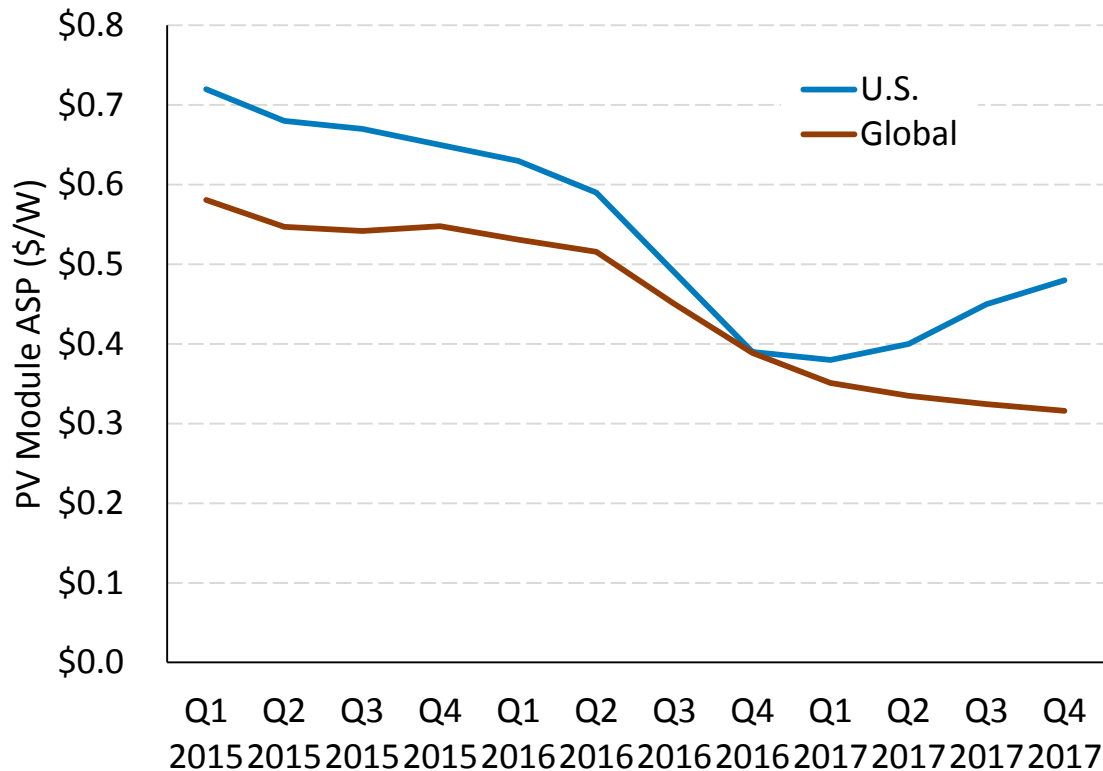
Component Pricing

PV Value Chain Spot Pricing



- BNEF reported a slow in price drop across the value chain in March 2018 due to anticipation of an active Q2 in China.
- Wafer prices fell the most in the first quarter of 2018 due to strong competition, followed by cells and polysilicon.
- BNEF also reported that Chinese manufacturers had a low shipment-to-capacity ratio in the first 2 months of 2018.

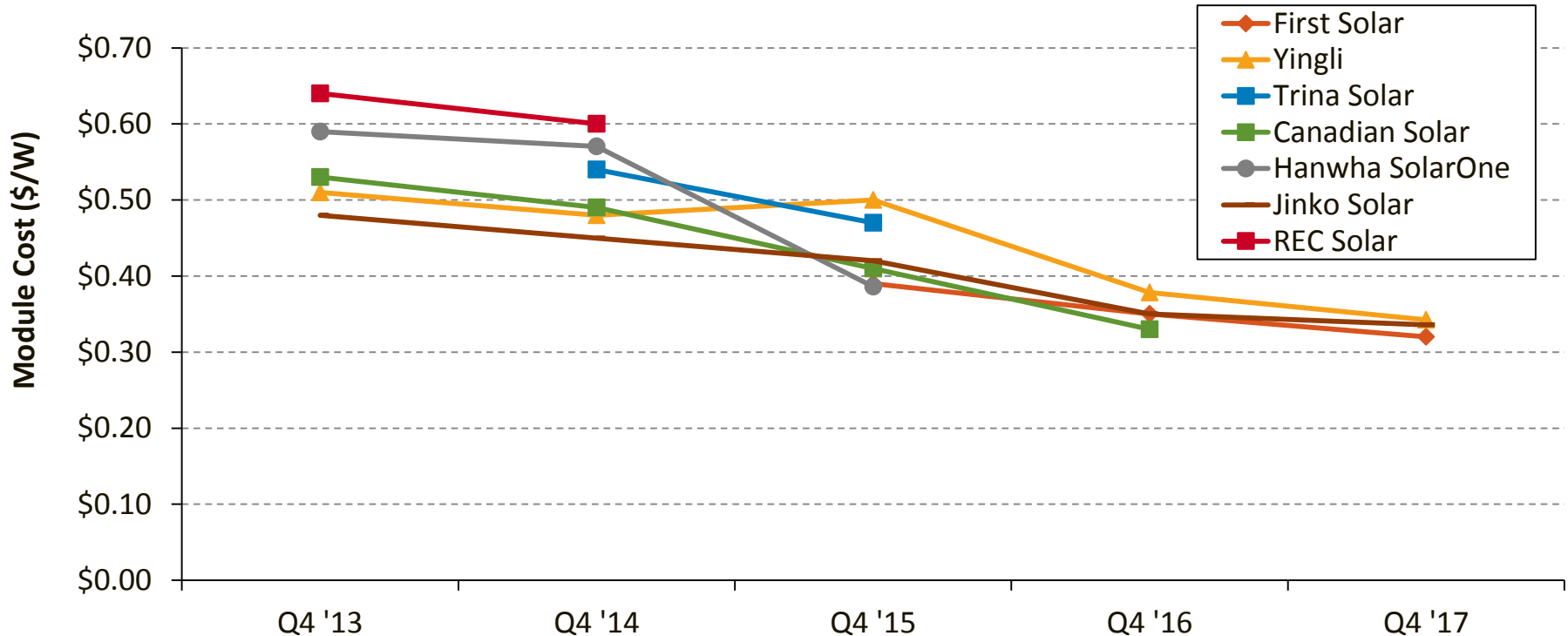
Module Average Selling Price— Global vs. U.S.



- Since tariffs were placed on Chinese modules in 2012, modules in the United States have sold at a premium to the global average
 - This trend was narrowing through 2016 due to increased manufacturing capacity in other parts of Asia.
- In 2017, the price gap widened again due to market fears of another tariff being placed on imported cells and modules.
 - Modules sold in the United States in Q4 2017 were 26% higher than modules sold in the United States in Q1 2017 and 52% higher than the global average.

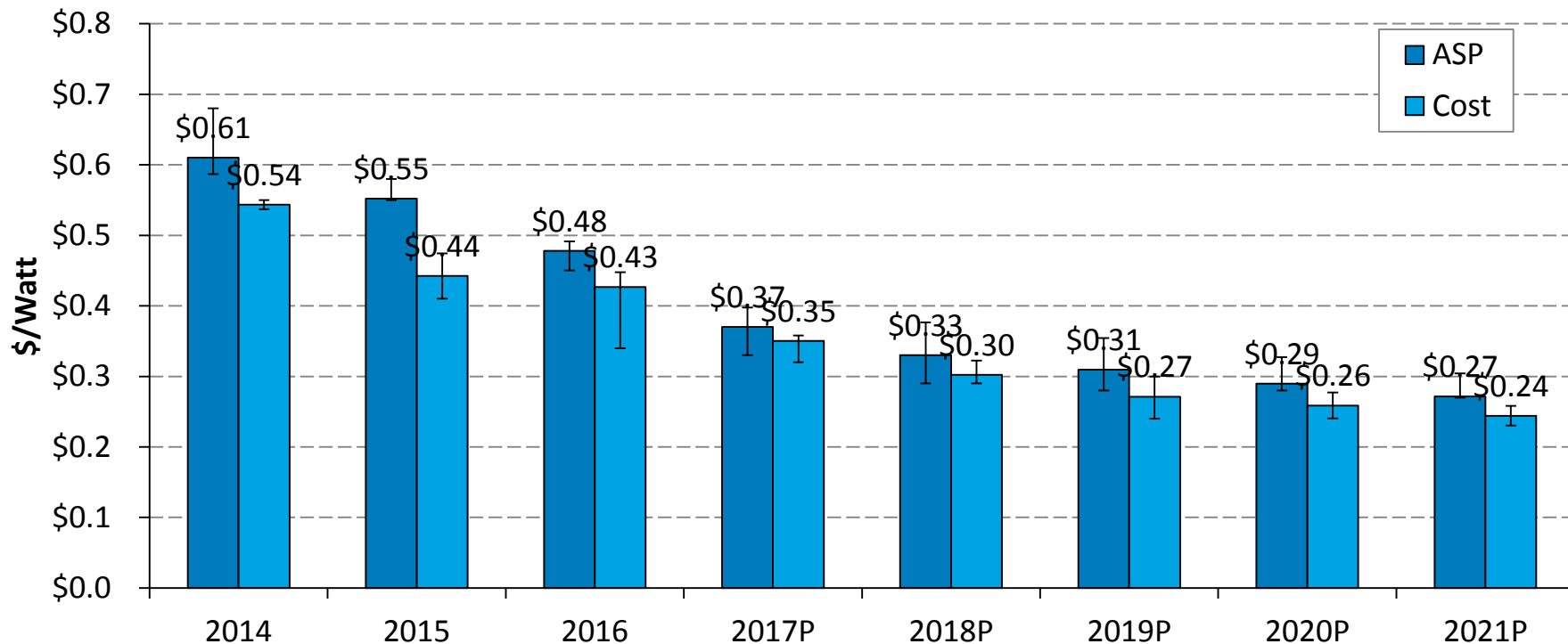
PV Manufacturers' Cost

In Q4 2017, module costs were reported between \$0.33 and \$0.35. As prices have come down, fewer and fewer companies are reporting prices.



Near-Term Module Price/Cost Projections

Regional module preferences and tariffs could impact actual pricing in the United States, Europe, India, and elsewhere.



Sources: Lines represent the median estimates, and error bars represent the maximum and minimum, ASP and costs for First Solar and industry averages from the following analysts: BNEF (February 2018); Deutsche Bank (February 2018); Goldman Sachs (May 2017, January 2018); GTM Research (December 2017); IHS Markit, Technology Group, PV Integrated Market Tracker, December 2017.

Thank You

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Special thanks to: Sarah Kurtz, Parthiv Kurup, Jeff Logan, Mary Lukkonen, Mark Mehos, Mike Meshek, Dave Mooney, and Craig Turchi.



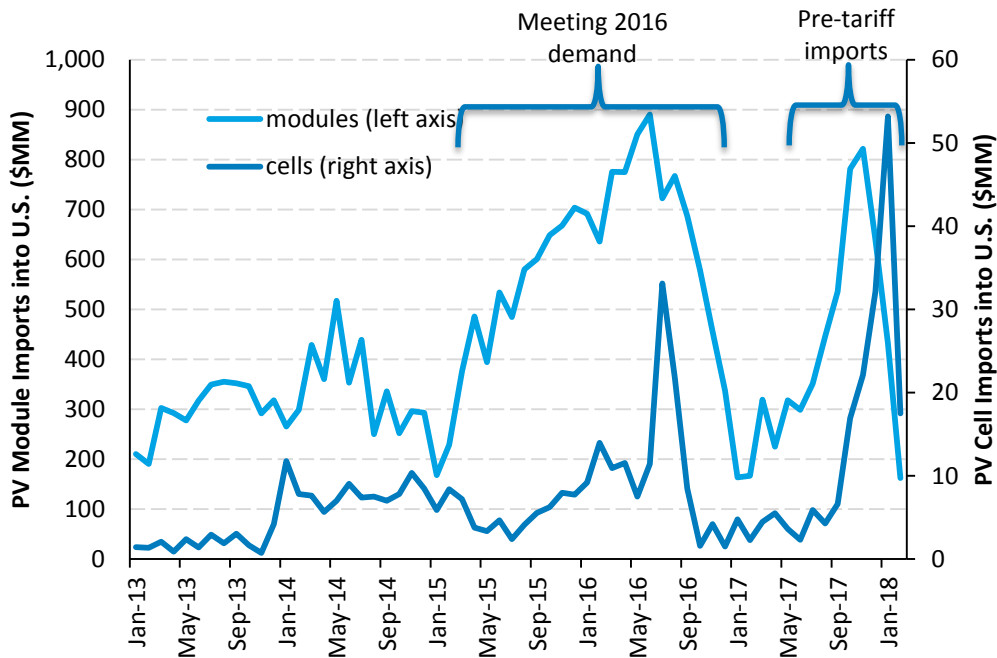
List of Acronyms and Abbreviations

• AC	alternating current	• MM	million
• ASP	average selling price	• MW	megawatt
• B	billion	• MWh	megawatt-hour
• BNEF	Bloomberg New Energy Finance	• NEM	net energy metering
• CAPEX	capital expenditures	• O&M	operation and maintenance
• CO ₂	carbon dioxide	• PERC	passivated emitter rear cell
• C-Si	crystalline silicon	• PPA	power purchase agreement
• CSP	concentrating solar power	• PSC	public service commission
• DC	direct current	• PV	photovoltaic
• DPU	department of public utilities	• Q	quarter
• DPV	distributed photovoltaic system	• R&D	research and development
• EIA	Energy Information Administration	• ROW	rest of world
• ETF	exchange traded fund	• RPS	renewable portfolio standards
• EU	European Union	• SEC	United States Securities Exchange Commission
• FiT	feed-in-tariff	• SG&A	selling, general, and administrative expenses
• G&A	general and administrative expenses	• SREC	solar renewable energy certificate
• GW	gigawatt	• UPV	utility-scale photovoltaic system
• IBC	interdigitated back contact	• USITC	United States International Trade Commission
• IPP	independent power producer	• W	watt
• ITC	investment tax credit	• WTO	World Trade Organization
• kW	kilowatt	• y/y	year over year
• kWh	kilowatt-hour		
• LCOE	levelized cost of energy		
• MLPE	module-level power electronics		

Section 201 Trade Case

Import Data

PV Module and Cell Imports into U.S. (\$MM)



- Historically there have been spikes in imported PV cells and modules to meet increased levels of demand (e.g., 2016).
- The spike in imported PV cells and modules into the United States from August 2017 to January 2018 was likely done to avoid potential Section 201 tariffs.
 - The imports are particularly pronounced when considering the drop in global costs of cells and modules.
 - During that 6-month period, an estimated 8 GW of PV cells and modules were imported into the United States.

State Actions on Distributed Solar—Q1 2018

- 40 states and D.C. took 149 actions on distributed solar policy and rate design during Q1 2018.

Policy Type	# of Actions	% by Type	# of States
Residential fixed charge or minimum bill increase	49	33%	26
DG compensation rules	39	26%	25 + DC
DG valuation or net metering study	21	14%	17 + DC
Community solar	18	12%	15
Residential demand or solar charge	10	7%	5 + DC
Third-party ownership of solar	8	5%	3+ DC
Utility-led rooftop PV programs	4	3%	4
Total	149	100%	40 States + DC

- In January 2018, Massachusetts DPU approved Eversource's mandatory demand charge for new net-metering customers—the first mandatory residential demand charge by an IOU in the United States.
- A Montana utility, NorthWestern Energy, published a cost-benefit study, finding the net value of solar to be between \$0.042/kWh and \$0.046/kWh, including CO₂, and between \$0.035/kWh and \$0.038/kWh without.
- Utilities in North Carolina and Virginia proposed community solar programs in Q1 2018 and New Jersey passed legislation in April 2018, enabling the establishment of community solar programs.

State Actions on Solar—April 2018

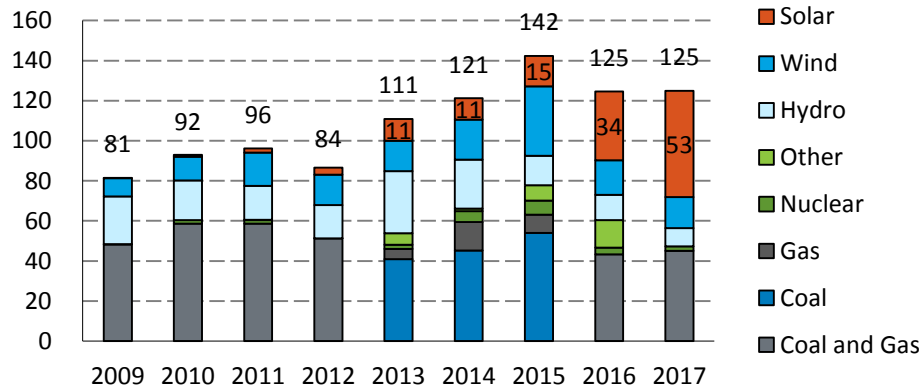
- Michigan PSC replaced its net-metering system with one that credits exported energy at “avoided cost.”
- Florida PSC voted to allow Sunrun to sell its lease product in the state. Florida still bars the third-party sale of electricity, but Sunrun made changes to its contract, including removing its performance guarantee.
- Hawaii governor signed a law mandating performance-based utility regulation, breaking the link between utility revenues and capital investments. The new business model will base revenues on metrics like customer satisfaction, renewable energy integration, and data sharing.
- New Jersey passed legislation to increase its RPS to 50% by 2030 and behind-the-meter solar to 5.1% by 2021.
 - The bills close the SREC program in 2021 and direct regulators to move to a different program for distributed solar.
 - The bill sets storage targets of 600 MW in 2021 and 2 GW in 2030 and enables the establishment of community solar programs.

Chinese Generation Capacity Additions by Source

- In 2017, solar contributed 42% to new generation capacity in China (53 GW) and 7% of cumulative capacity (130 GW).
 - 2017 is the first year that wind and solar contributed over half of all new electric generation in China (55%).
 - Chinese annual electric generation capacity additions have been around six times greater than additions by the United States for the past 5 years.

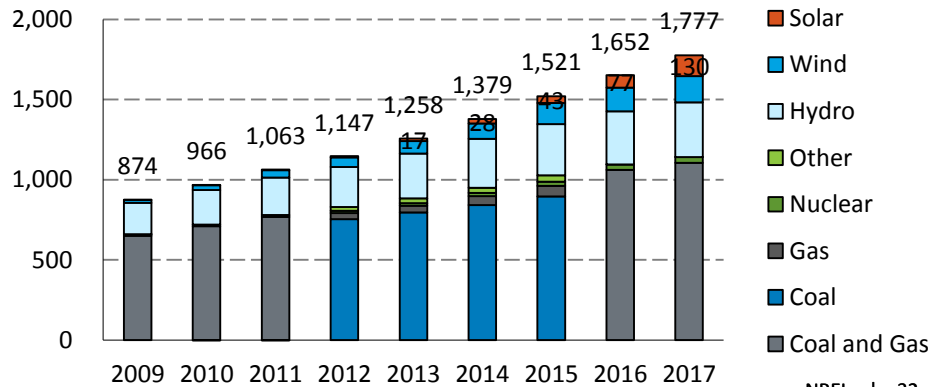
- As China grows its electricity infrastructure, it has rapidly incorporated non-carbon sources of electricity generation.
 - Since 2009, China has doubled its installed electric generation capacity, and at the same time reduced the percentage of total coal and gas capacity from 74% to 62%.
 - From 2010 to 2016, new thermal generation capacity as a percent of total new capacity was reduced from 63% to 36%.

Annual Capacity Additions (GW)



Source: China Electric Council, accessed (2017, 2018).

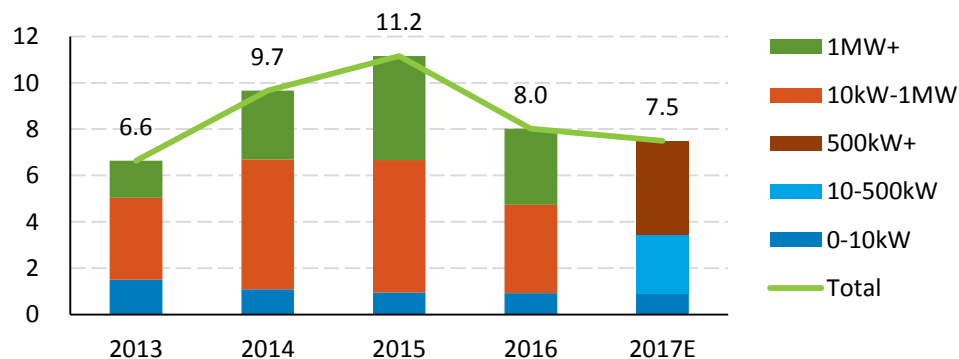
Cumulative Capacity (GW)



Japanese Market Update

- BNEF estimates that approximately 7.5 GW of PV was installed in Japan in 2017, bringing cumulative deployment to 49 GW.
- While Japan's PV industry had focused in the residential sector before the FiT, it is relying more heavily on larger projects.
- Japan held its first solar auction in 2017; however, only 141 MW of a possible 500 MW were successful. Japan is hoping with less strict rules, two more auctions for up to 250 MW of PV projects larger than 2 MW, will be successful in 2018.

Annual Japanese PV Deployment (GW-DC)

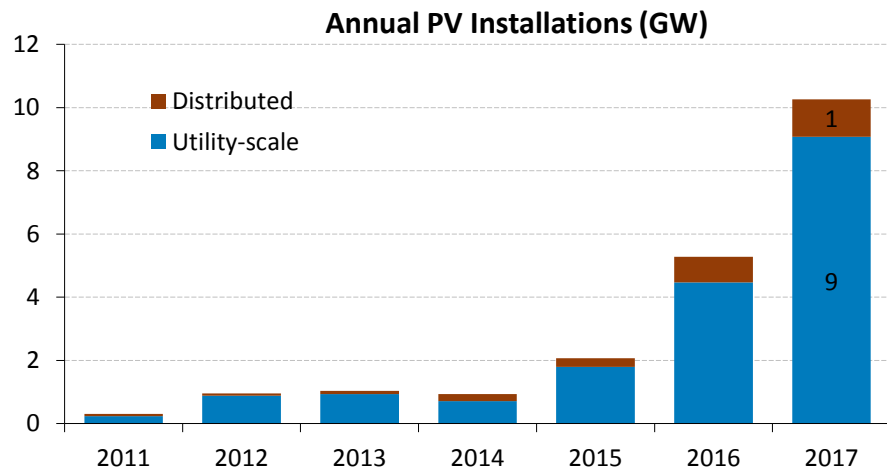


Source: BNEF, "1H 2018 Japan Market Outlook." March 2018.

- Starting in July 2016, projects must secure grid connection approval within 9 months of their FiT approval. Japan has thus far revoked FiT allocations from 15 GW of mostly PV projects.
- As Japanese households come off their FiT, there is new interest in finding ways to optimize solar use. A Japan utility and university introduced a trial "virtual power plant," which shifts heat pump use from night to the middle of the day if excess PV production is predicted. Japan currently has more than 5 million heat pumps.
 - Japan installed 149 MWh of energy storage in 2017, bringing its total to approximately 1.2 GWh (along with record EV sales).
 - Curtailment occurred 42 times in 2017 (compared to 17 in 2016) however, all were on remote islands in periods of low demand.
- In 2017, imported coal reached an all-time high and LNG imports increased as nuclear starts were delayed.

Indian Market Update

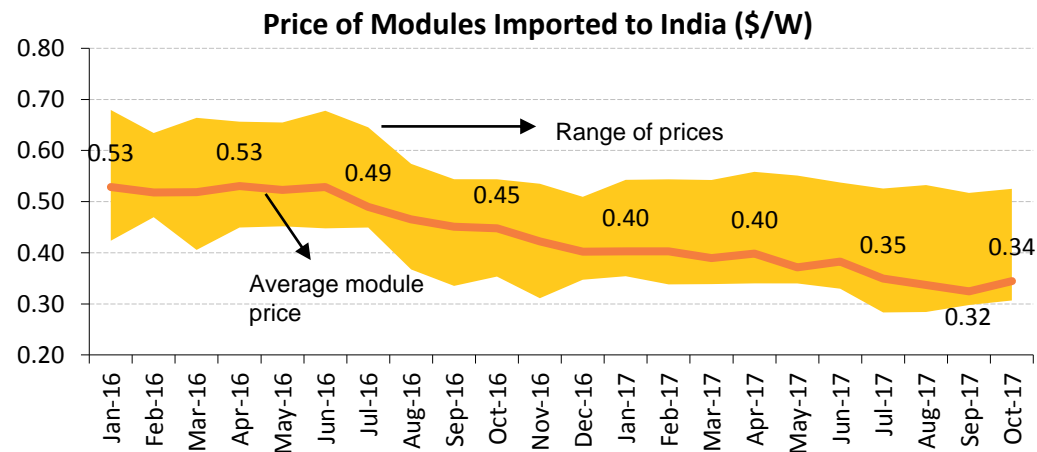
- BNEF estimates that approximately 10 GW of PV was installed in India in 2017, bringing cumulative deployment to 21 GW.
- An increase in module prices and the ambiguity over tax rates delayed installation of several projects in H2 2017.
- India aims to bring 80 GW of PV (and 28 GW of wind) to auctions in 2018 and 2019 as they try reach their 175 GW target of renewables by March 2022.



Source: BNEF, "1H 2018 India Market Outlook." January 2018. BNEF, "Capacity & Generation" data set. Accessed April 23, 2018.

- The Indian government has not yet given clarity to solar project developers on the final goods and service tax rates applicable to various solar components, causing uncertainty to project economics.
- As solar auctions have become fewer and more competitive, Indian IPPs are pursuing ways of raising cheaper capital through mergers and acquisitions, IPOs, or through selling existing portfolios of operating projects. Indian firms raised \$712 million in new equity investments and another \$3.8 billion through green bonds in 2017.
- Four Indian States have finalized regulations that penalize renewable energy power producers for being unable to forecast electricity generation within 15%.

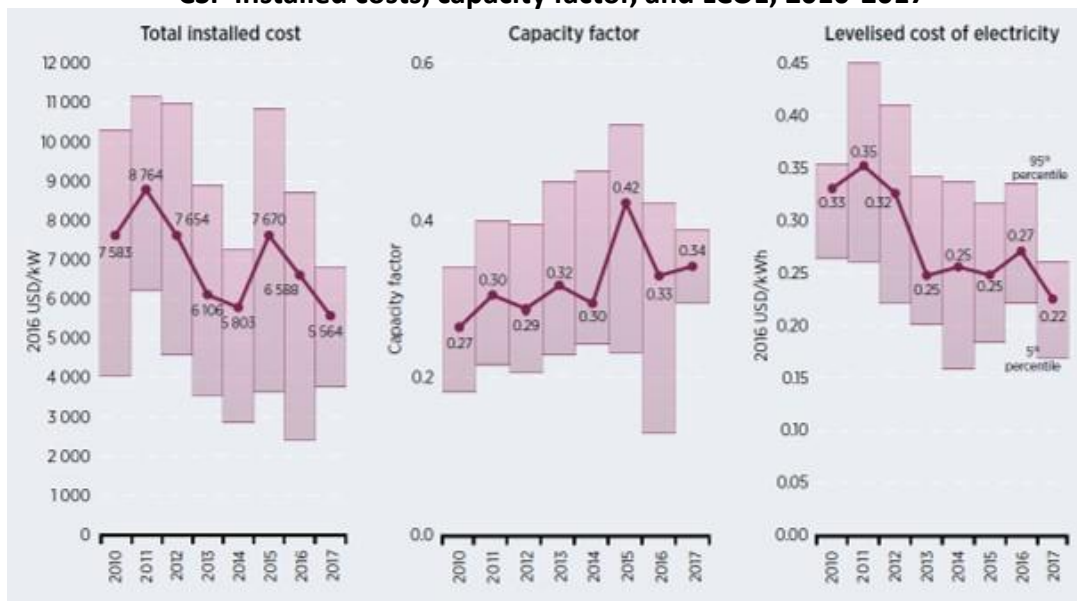
Indian PV Manufacturing Update



- In July 2017, India initiated an anti-dumping investigation regarding modules manufactured in China, Malaysia, and Taiwan. In January 2018, a preliminary recommendation of a 70% safeguard duty was announced, which developers felt would severely impact the industry. In March 2018, Indian manufacturers announced they were withdrawing their petition so that they could refile with more contemporary data, causing India to terminate their investigation. Indian manufacturers plan on filing a new petition this year.
 - Electricity contracts auctioned in H2 2017 ranged between \$38/MWh and \$64/MWh—up to 68% higher than some bids in H1 2017.
- Due to fears of Indian module quality, the government issued orders to establish quality control standards for solar equipment. The order bans the manufacturing or sale of equipment that has not achieved these standards. The standards took effect April 1, 2018.

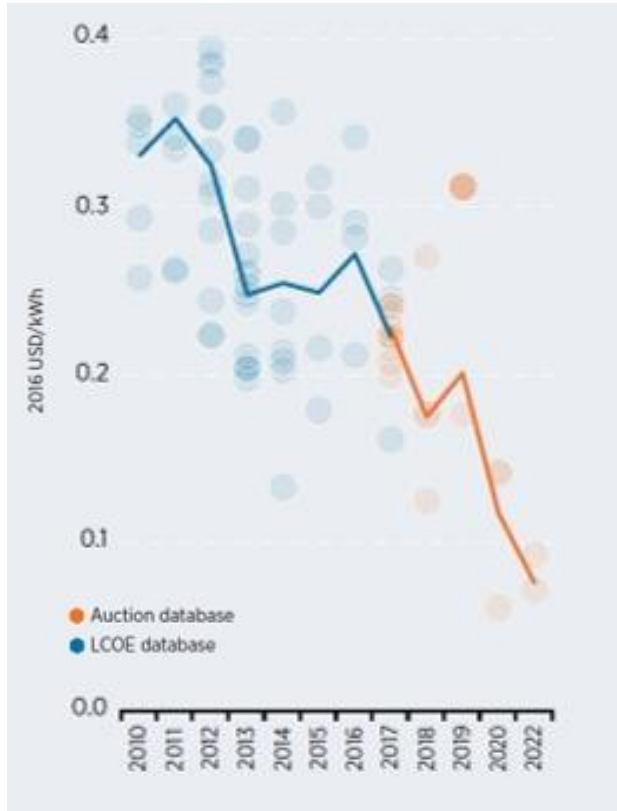
Global CSP Cost and Performance

CSP installed costs, capacity factor, and LCOE, 2010-2017



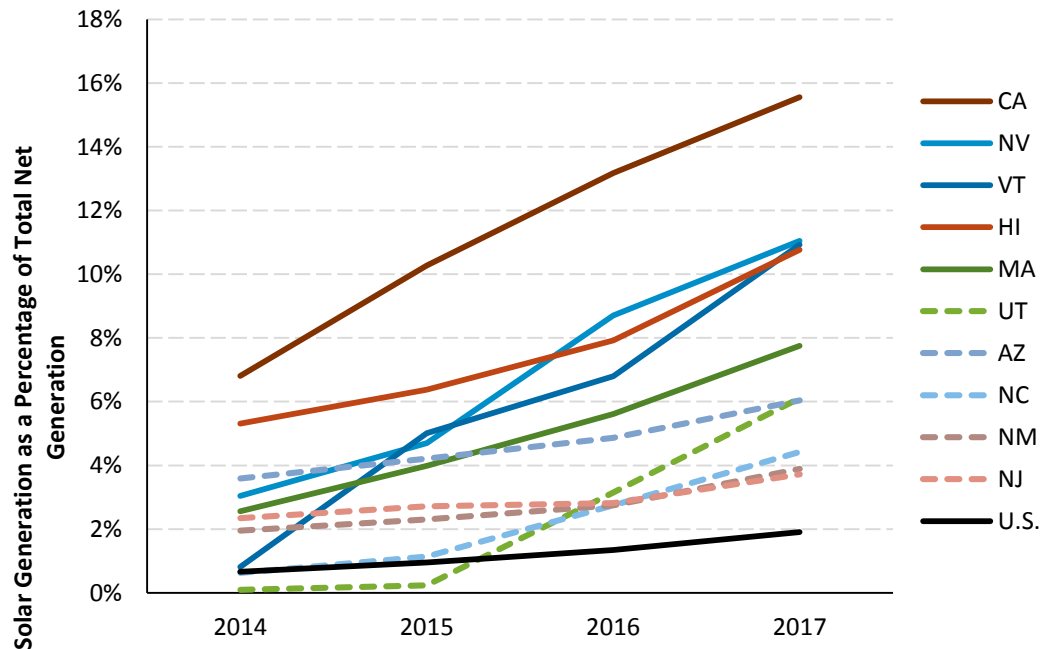
- IRENA reported 2017 global-weighted average installed costs and LCOE for CSP fell 27% and 33% from 2010 to 2017, respectively.

Global CSP LCOE



- Despite a global average LCOE of \$0.22/kWh in 2017, IRENA reports that recent auctions will put CSP pricing between \$0.06/kWh and \$0.10/kWh by 2022.

Solar Generation as a Percentage of Total Generation, 2014-2017



Note: EIA monthly data for 2017 are not final. Additionally, smaller utilities report information to EIA on a yearly basis, and therefore, a certain amount of solar data has not yet been reported. "Net Generation" includes DPV generation. Net generation does not take into account imports and exports to and from each state and therefore the percentage of solar consumed in each state may vary from its percentage of net generation.

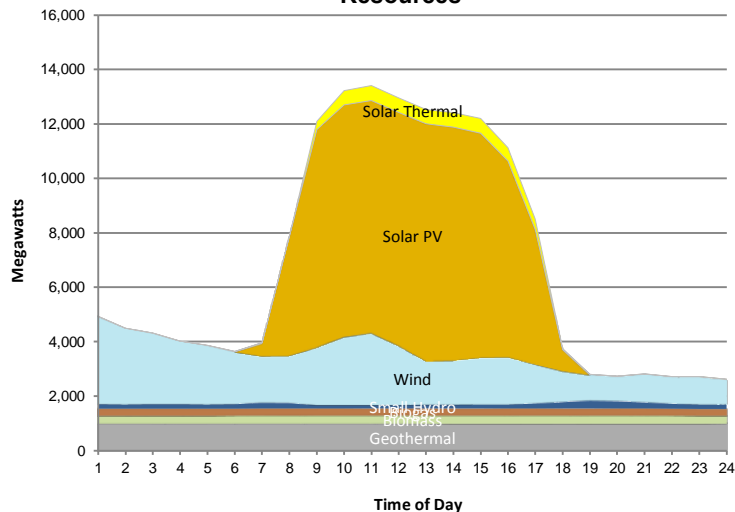
Sources: EIA, "Electric Power Monthly," forms EIA-023, EIA-826, and EIA-861 (February 2018).

- The 10 states with the highest percentage of solar penetration generated at least 3.5% of their energy from solar in 2017, with California leading the way at 15.6%.
 - In 2014, California led the United States with 6.8% of total generation coming from solar.
 - Utah's percentage of electricity generation coming from solar grew from 0.2% in 2015 to 6.1% in 2017.
- In 2017, the United States as a whole produced approximately 1.9% of its electricity using solar technologies.
 - This represents an approximate 2X growth from 2014 (0.7%).

In California, Sometimes Non-Hydro Renewable Electricity is > 50%

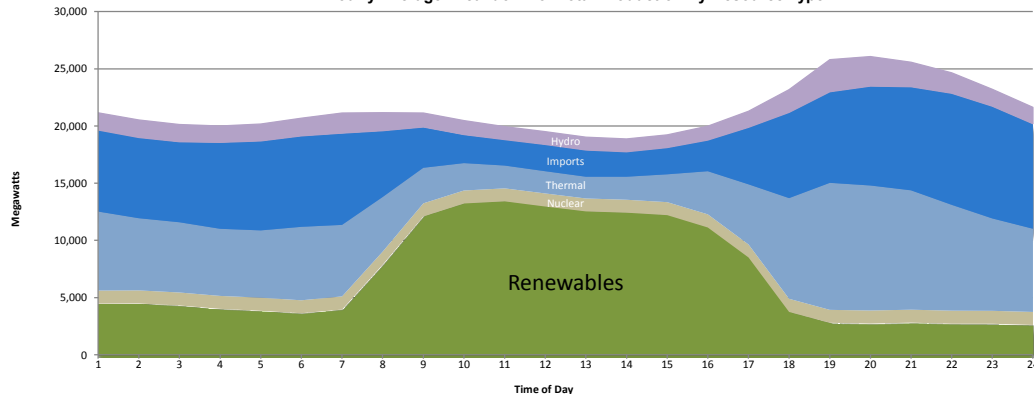
- Similar to Germany, much of the balancing is done using imports.
 - 6 GWh (~1% of total) were curtailed, and 2 GWh were exported on April 8, 2018.

Hourly Average Breakdown of Renewable Resources

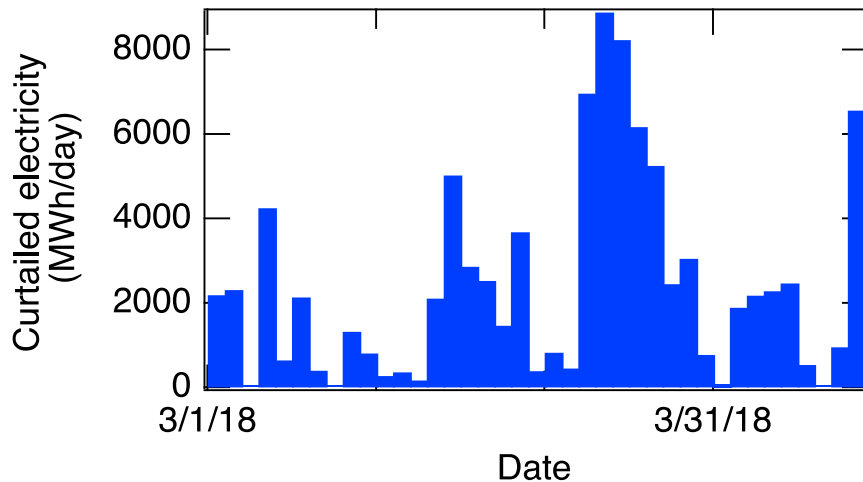


- California's all-renewable electricity hit 83% from 1 p.m.-2 p.m. on April 8, 2018 (54% for day).
 - ~9 GW (47%) came from solar electricity.
 - ~13 GW (68%) came from non-hydro renewable electricity.
 - 19-20 GW of total demand.

Hourly Average Breakdown of Total Production By Resource Type

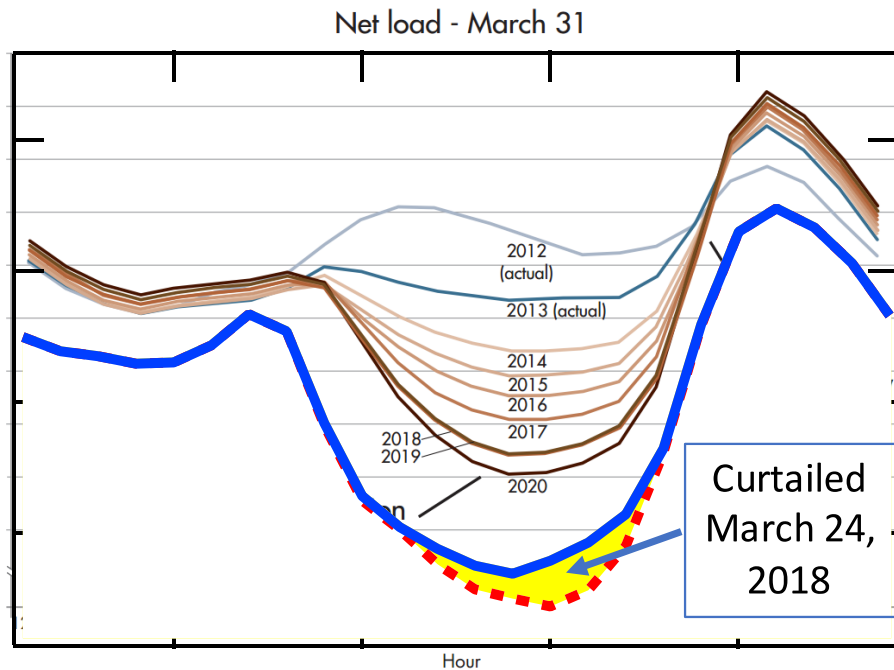


Curtailed Electricity in California in 2018



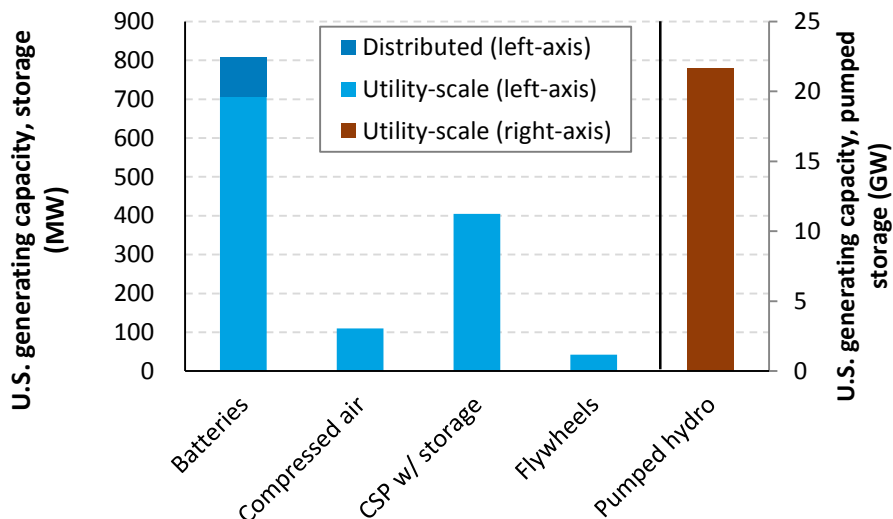
- As of April 8, 2018, the curtailed electricity year-to-date in California was 132,728 MWh.
- If that electricity is valued at \$0.10/kWh, curtailment results in ~\$13MM in lost revenue.

Watching the Duck Grow Fat



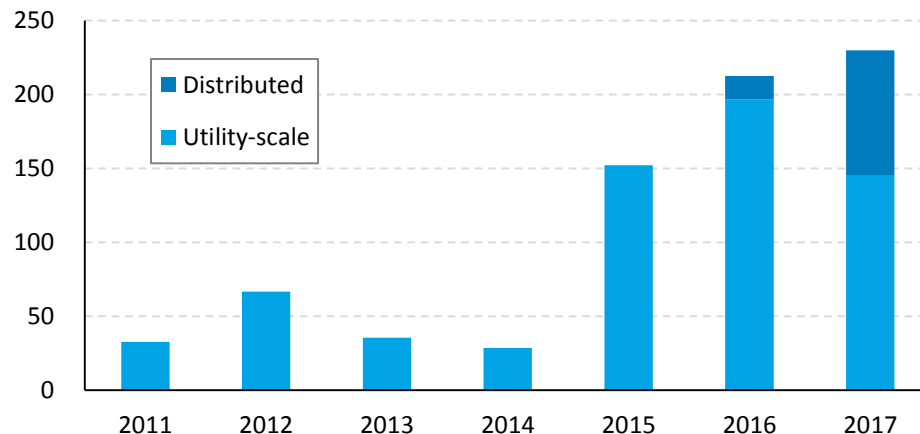
U.S. Storage Capacity Additions by Source

- Pumped hydro continues to be the largest source of energy storage in the United States by an order of magnitude; however, a significant number of batteries have been added to the grid over the past few years due to the rise in renewable capacity and the reduction in battery costs.

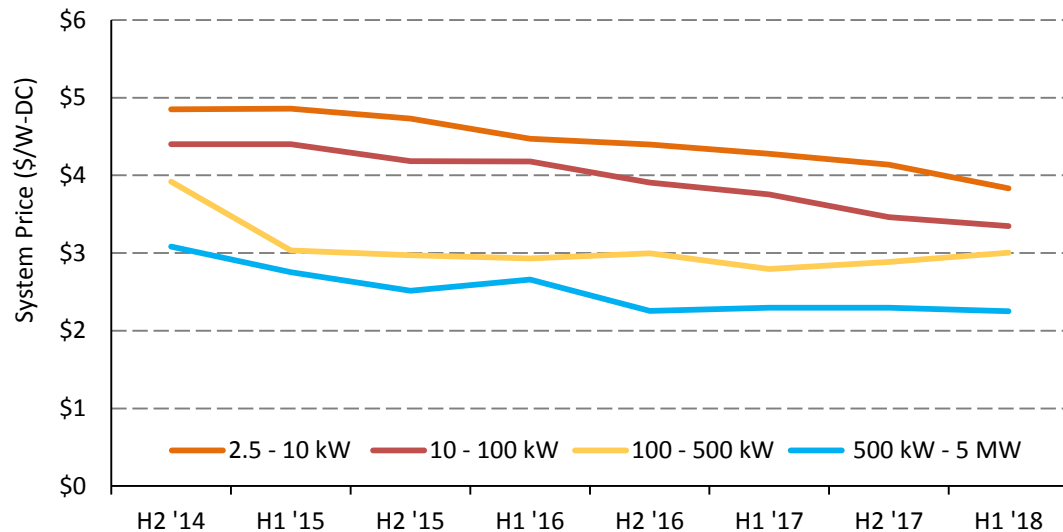


- EIA reports that at the end of 2017, the United States had **708 MW of utility-scale electric generation battery storage, up 145 MW from 2016, and 101 MW of distributed storage, up 85 MW from 2016.**
- Battery storage still represents a small resource when compared to the 130 GW of PV and wind installed in the United States at the end of 2017.
- New Jersey passed a bill in April 2018 that sets storage targets of 600 MW in 2021 and 2 GW in 2030.

U.S. Electric Generation Battery Storage Additions (MW)



System Pricing From Select States



Based on preliminary data for H1 2018, from H1 2017 to H1 2018, the median reported PV system price in the four states analyzed:

- Fell 10% to \$3.83/W, for systems 2.5 kW–10 kW
- Fell 11% to \$3.34/W, for systems 10 kW–100 kW
- Increased 8% to \$3.00/W, for systems 100 kW–500 kW
- Fell 2% to \$2.25/W, for systems 500 kW–5 MW.

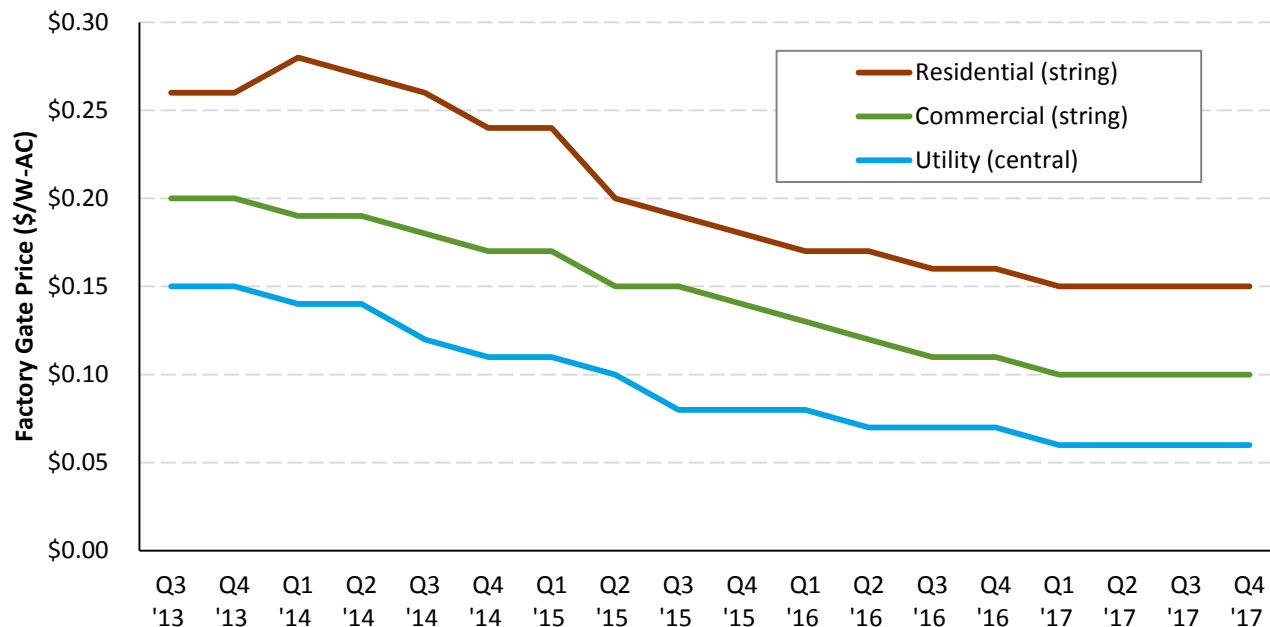
Preliminary H1 2018 MW: AZ (48), CA (47), MA (13), NY (72)

Note: California pricing data before 2015 are collected from the California Solar Initiative database. CA NEM data have only been reported through November 2017.

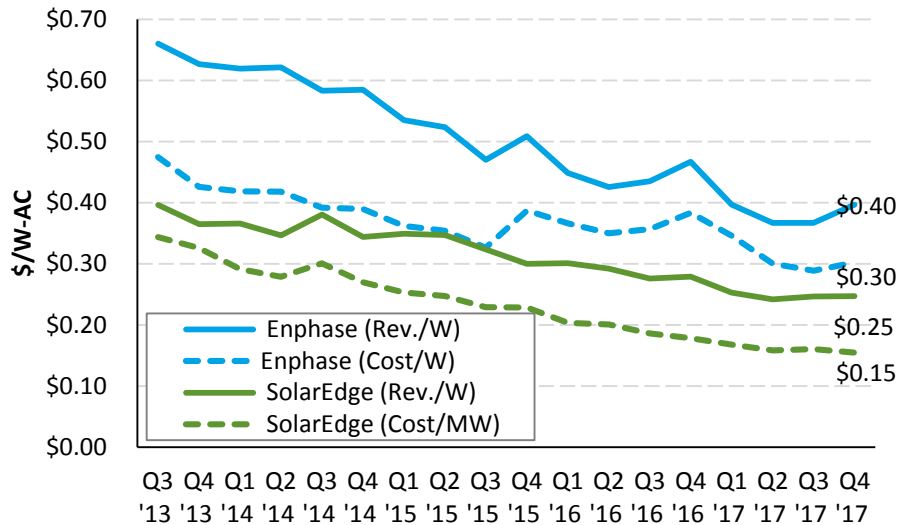
Sources: CA NEM database; MA SREC program; Arizona Public Services and Salt River Project; NY PV Incentive Program. All programs accessed 01/17/2018.

Inverter Pricing

- Since Q3 2016, the decrease in inverter price has slowed.
 - In 2017, string and central inverters have been flat.



Enphase Microinverters and SolarEdge DC-Optimized Inverter Systems

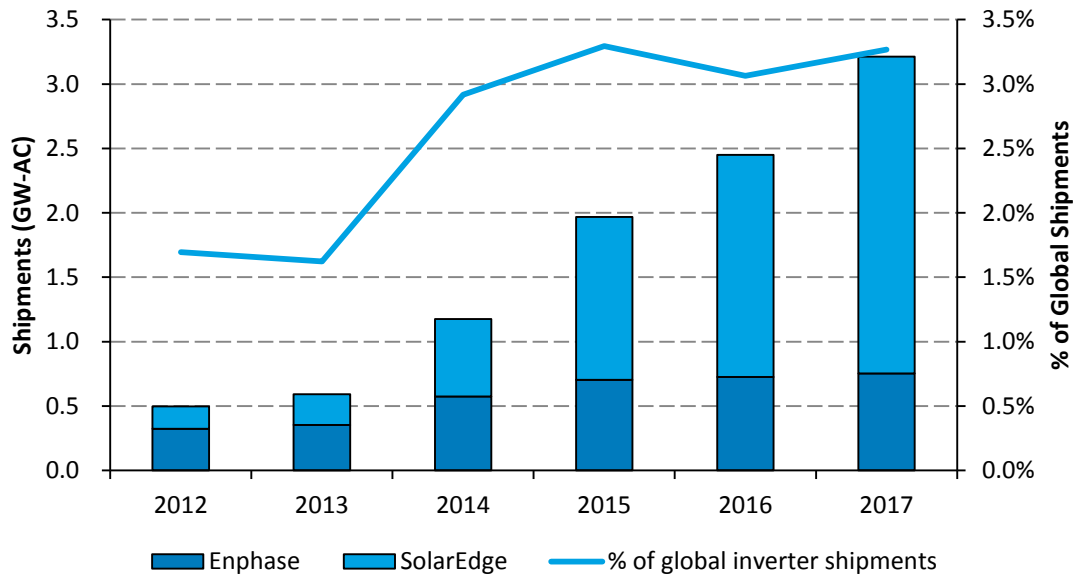


- In 2017, module-level power electronics (MLPE) price and costs were at historical lows and shipments were at historical highs—companies are expanding into new markets, growing shipments but also growing competition.
 - From Q4 2016 to Q4 2017, Enphase and SolarEdge MLPE prices fell 15% and 11%, respectively.
 - Enphase and SolarEdge MLPE costs also decreased by 21% and 13%, respectively, over the same period.
 - These companies have cut operating costs and are transitioning to more advanced technologies to better compete in this highly competitive marketplace.

Note: Starting in Q2 2017 Enphase switched reporting shipments from W-AC to W-DC; we adjust these values using an ILR of 1.1,

Sources: Corporate filings.

Enphase Microinverters and SolarEdge DC-Optimized Inverter Systems

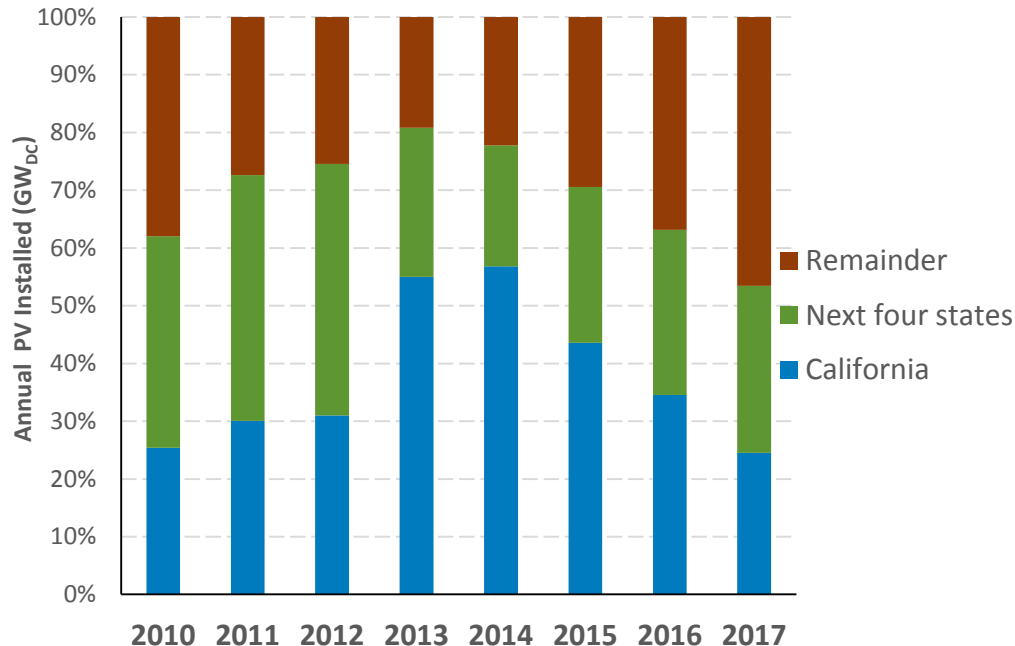


- Enphase and SolarEdge shipped over 3 GW-AC of MLPE combined in 2017.
 - Since 2015, Enphase shipments have been relatively flat while SolarEdge shipments have grown 40% per year.
 - In Q4 2017, SolarEdge’s MLPE product was approximately \$0.15/W cheaper than Enphase’s product.
- Enphase and SolarEdge represented approximately 3.3% of all inverter shipments in 2017.
 - GTM Research reports that these companies represented approximately 66% of U.S. residential PV system inverters installed in 2017—up from 57% in 2016.

Executive Summary

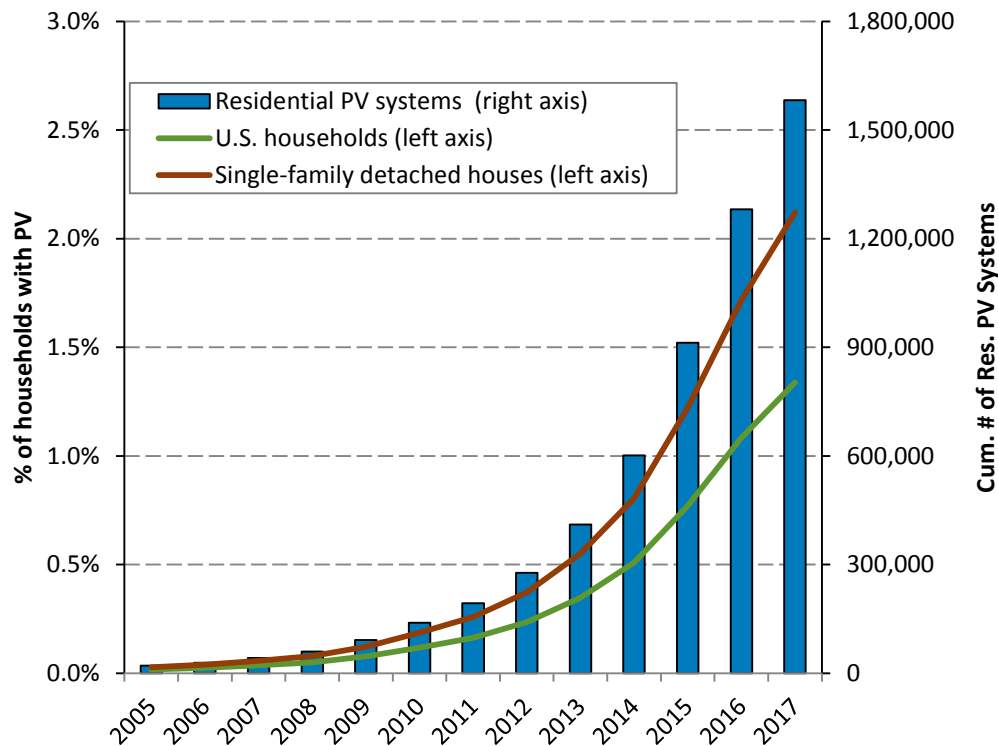
- The **United States** installed **10.6 GW-DC** of PV in **2017**, 3.9 GW-DC in Q4—**cumulative capacity** reached **51.6 GW**.
- After tariffs were placed on imported PV cells and modules, several countries have taken steps to dispute the proclamation and companies are seeking exemptions.
- Over **2 GW of new manufacturing capacity** has been **announced** in the first 4 months of 2018, **citing tariffs and corporate tax reductions**.
- In **2017**, the **U.S.** produced approximately **260 MW** of PV **cells** and **970 MW** of PV **modules**—a **decrease** of 66% and 43%, respectively, year over year.
- Global PV installations reached **415 GW-DC**, an annual increase of 98 GW-DC from 2016.
- At the end of 2017, **global CSP installations** reached **5.6 GW**, an increase of 400 MW.
- EIA reports that **32%** of all **new U.S. electricity generating capacity** came from **solar** installations in **2017**, though solar **only** represented **3.9% of net summer capacity** and **1.9% of annual generation** in 2017.
- From H2 2016 to H2 2017, EnergySage reported a 7% reduction in the average gross costs of a **residential system to \$3.13/W**.
- In Q4 2017, total costs for Vivint- and Sunrun-built systems were between \$2.65/W and \$3.00/W.
- In a select data set of utility-scale PV systems, the median system price in 2017 was \$2.16/W-AC (\$1.66/W-DC).
- **Global module ASP** continues to decline to a low of **30 cents/W**, while many **manufacturers** report module **costs at similar values**.
- U.S. module pricing traded at a premium in late 2017 due to tariff concerns.

U.S. Installation Breakdown



- The top five states represented approximately 53% of the U.S. PV market in 2017—the lowest level in at least 12 years.
 - Part of that reason is that in 2017, the California market contracted, y/y, for the first time in over 12 years.
 - States outside of the top five contracted 11% from 2016 to 2017; however, installed capacity was still 124% higher than 2015 values.

U.S. Residential PV Penetration

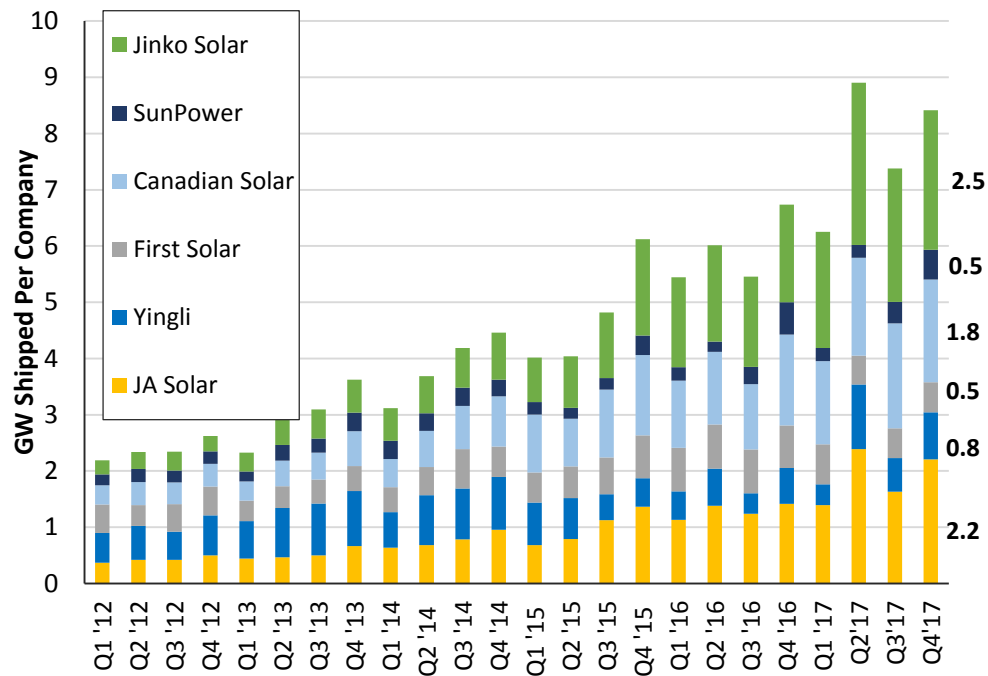


Sources: Res. PV Installations: 2000-2009, IREC 2010 Solar Market Trends Report; 2010-2017, SEIA/GTM Solar Market Insight 2017 Year-in-Review; U.S. Households U.S. Census Bureau, 2015 American Housing Survey; state percentages based on 2000 survey.

- Since 2005, when the investment tax credit was passed by congress, the residential PV market has grown by approximately 44% per year, or about 81X.
- U.S. residential PV has had customer acquisition challenges amidst widespread NEM reform, loss of state incentives, and potential saturation of early adopters.
- Penetration varies by location. Hawaii, California, and Arizona have residential systems on an estimated 31%, 11%, and 9% of households living in single-family detached structures.

Manufacturers' Shipments

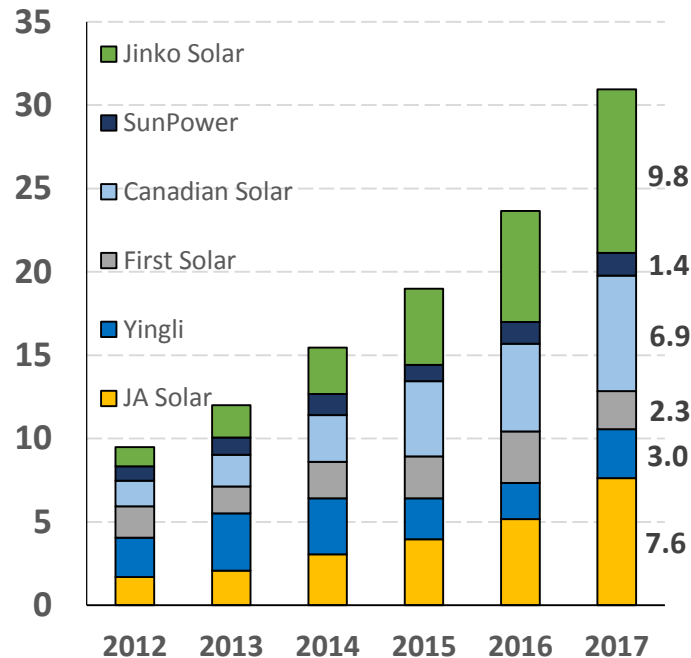
Publically Traded Cell/Module Manufacturers



Notes: First Solar reports data on production, not shipments.

Sources: Company figures based on Q4 2017 (and previous) SEC filings by the respective companies.

- In 2017, the tracked companies shipped 31 GW, an increase of 24% over 2016.
- Q2 shipments were greater than Q4 shipments due to the reduction in Chinese FiT rates in H2.

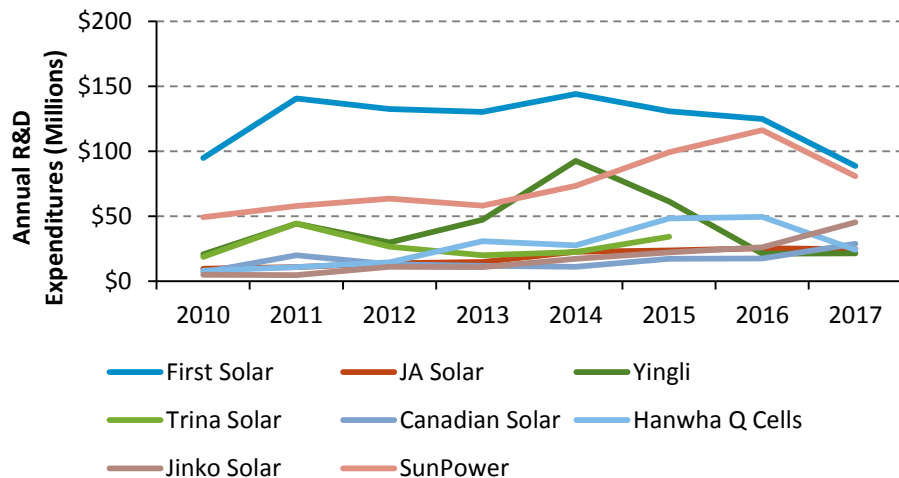


Research and Development

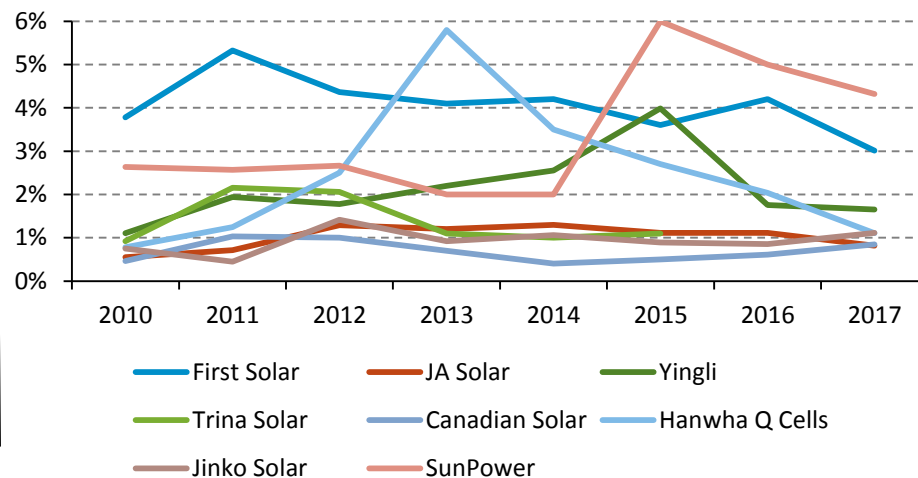
- R&D among the tracked companies fell significantly to \$313 million in 2017 from \$380 million in 2016, a fall of 18% y/y.

- First Solar continues to lead in R&D spending, although SunPower is a close second. Both companies cut R&D funding significantly in 2017.
- In past years, Canadian Solar and Jinko Solar have had relatively small R&D budgets but increased R&D spending this year by 65% and 73%, respectively.

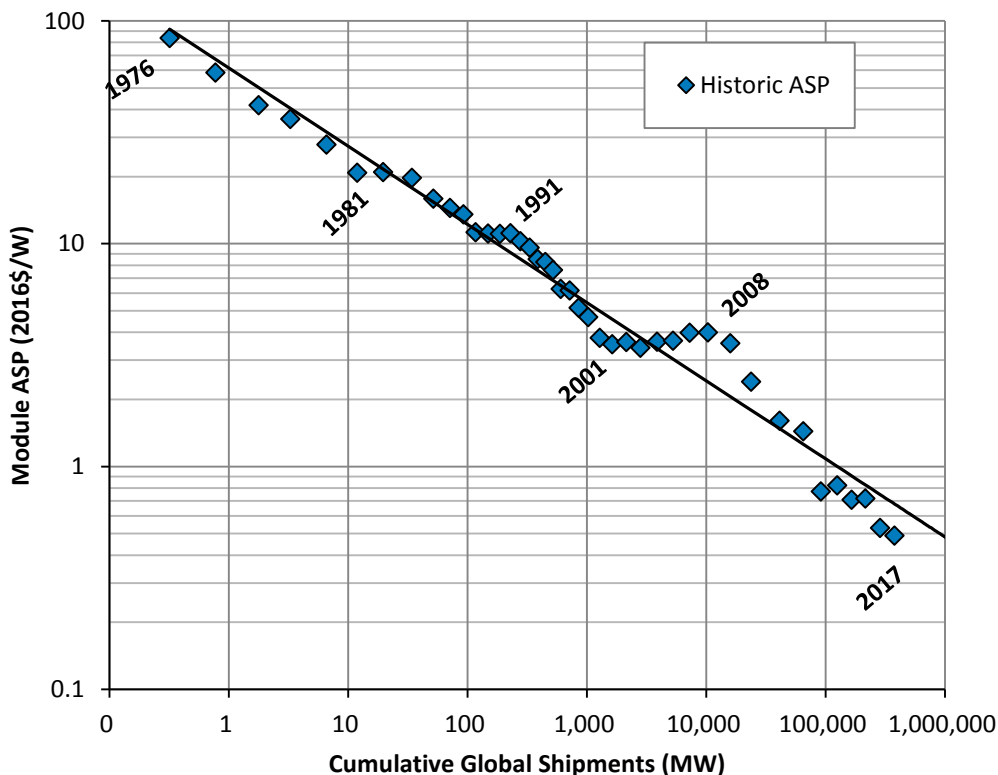
R&D Expenditures



R&D as a Portion of Revenue

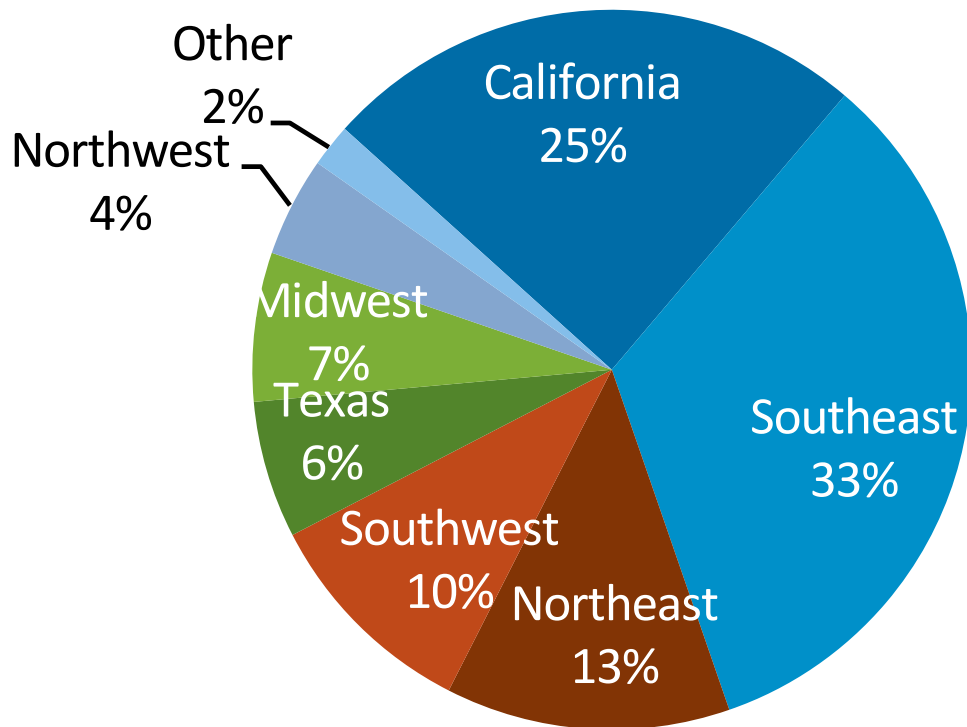


PV Experience Curve



- This experience curve displays the relationship, in logarithmic form, between the average selling price of a PV module and the cumulative global shipments of PV modules. As shown, for every doubling of cumulative PV shipments, there is on average a corresponding ~22% reduction in PV module price.
- Since 2012, module ASP has been below the historical experience curve.

U.S. Installation Breakdown



In 2017, new PV installations have had a fair geographic mix across the United States, with 5 GW-DC installed east of the Mississippi.